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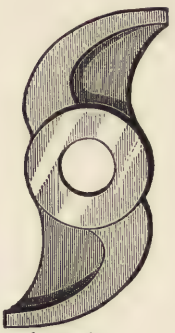

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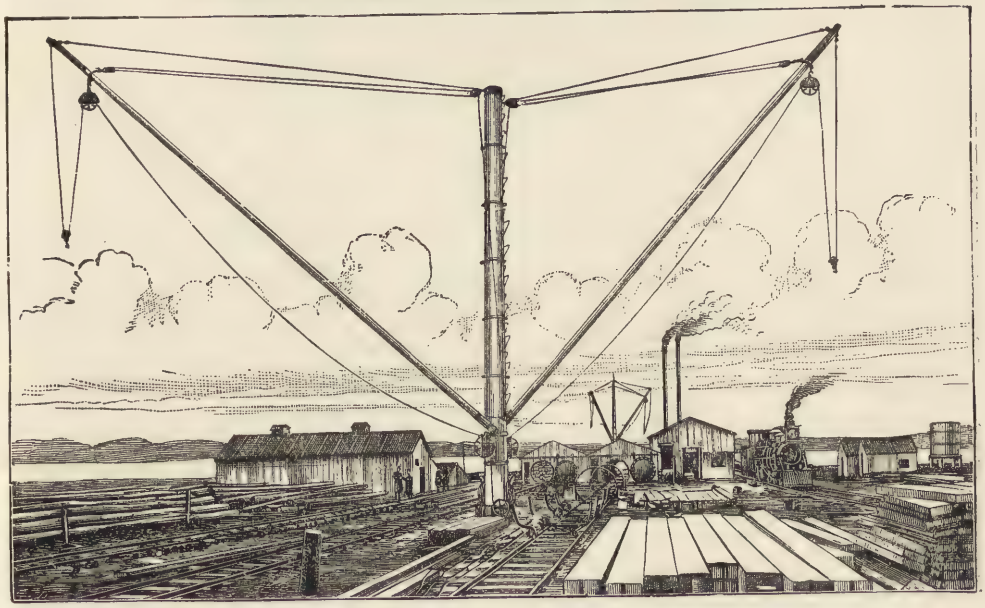

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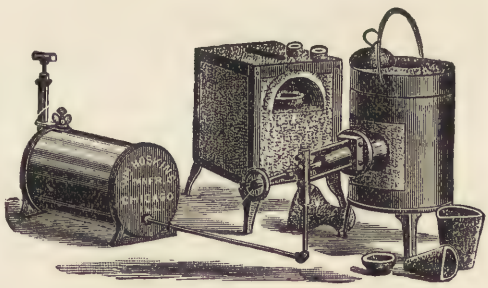

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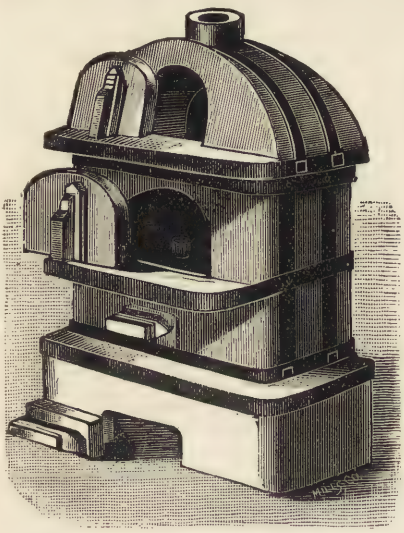

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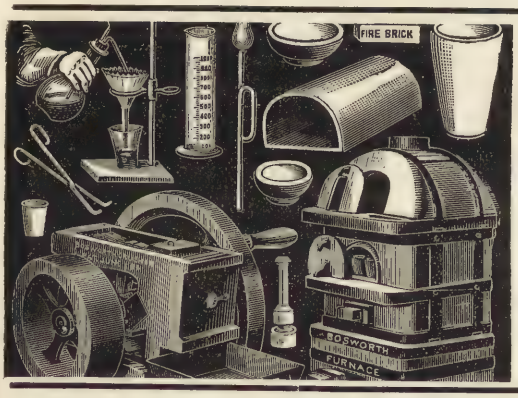

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OF THE

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IN THE

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TO THE END OF

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RICHARD P. ROTHWELL,

Editor of the Engineering and Mining Journal; Ex-President American Institute of Mining Engineers; Member American Society of Civil Engineers; Fellow Royal Statistical Society, London, Etc., Etc., Etc.

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PREFACE TO VOLUME II.

In introducing the second volume of this work it is appropriate to show the objects in view when this stupendous undertaking was inaugurated. The following extracts from the preface to the first volume outline these aims, and the well-filled pages of the volumes themselves testify, in the most conclusive manner, to the success with which they are being attained.

"This volume is a result of the development of the annual statistical numbers of the *Engineering and Mining Journal*, and owes its existence to the appreciation with which these statistics have been received by business men, by experts, and by others interested in the mineral industry throughout the world.

"The modern newspaper has made promptness in furnishing information not only familiar but indispensable to the man of affairs, and accurate and timely statistics have now become absolutely necessary for the intelligent direction of industry, trade, and legislation. The collection of such statistics in an industry which extends over the face of the entire globe is, however, a work so vast and difficult that it has hitherto been considered impossible except through the unlimited resources of governments; and as the machinery of government is not adapted to the rapid attainment of results, the statistics of the mineral industry have been so tardily collected and published in all countries that their value has been greatly impaired. . . . For many years the *Engineering and Mining Journal*, as the leading representative of this great industry, has accumulated vast stores of statistical information relating to it, and has greatly improved the machinery for the collection of statistics. . . .

"The universal appreciation of the work done by the *Engineering and Mining Journal* called for its extension, and consequently in this initial volume there are given, for the first time, the statistics of substantially all the minerals and metals produced in the United States and in many other countries for the full year 1892, and often from the earliest times. This series of annual volumes it is intended shall, in due time, cover the entire mineral industry of the world, giving its statistics, its technology, and its trade, each succeeding volume not repeating

the data given in previous issues, but supplementing them, and carrying forward the current history of the industry almost to the day of publication. Unaided by any governmental powers to enforce the making of returns, we have relied for success solely upon personal courtesy and confidence and upon the intelligent appreciation of the value of the work to the industry at large, and this great volume is the monument we have erected to the courtesy of those whose prompt and willing co-operation has alone rendered its success possible. Long experience in this kind of work has fully demonstrated the fact that men are in general more willing to give important and correct information to the private individual who can be held responsible for its proper use than to the more or less impersonal 'government.' It is indeed extremely rare that any producer neglects or refuses to give full, truthful, and satisfactory replies to our requests for information. . . .

"Accuracy should always be the first care of the statistician, but it is scarcely less important to the business man that the information should be promptly furnished. Belated statistics are ancient history, of little practical value in the active affairs of an industry, or as a guide for legislation affecting it. . . . Subjects which are uppermost in the business world naturally demand the greatest attention in this industrial work. . . .

"Much attention has been devoted to the subject of cost of production. The itemization of cost is the first essential step in securing economy in producing any article, and the history of every country and of every industry has shown that prosperity, whether national, industrial, or individual, is, in a general way, inversely proportional to the cost of supplying the rest of the world with what one produces. The great economies which command the markets for products are due, not to reductions in wages, but to increased knowledge and intelligence, and are accompanied by higher remuneration and a betterment of the condition of those engaged in the industry. . . .

"It is the object of the *Engineering and Mining Journal* to give in detail, and of this supplemental volume of the *Journal* to summarize, the facts which show how such results are accomplished; to photograph, as it were, from time to time, the condition of the several departments of the mineral industry in various parts of the world, placing within the reach of all the information that intelligence can apply to the reduction of cost in producing and marketing the useful minerals and metals and in promoting the welfare of those engaged in this industry. In every country this information will enable those who legislate for and those who administer this industry to do so with an intelligent appreciation of the conditions affecting it in its every department, and, widely disseminated, will promote the national prosperity.

"It is with the very greatest regret that we have been obliged in this work to use other than the metric system of weights and measures, which are now legalized in nearly every civilized country and should be universally adopted. The necessity of conforming to custom and popular prejudice in a work so expensive as this explains the use here of that nightmare of weights and measures which, as a relic of barbarism, survives and is used in all English-speaking countries as 'the English system.' We have, however, where possible, reduced the number of varieties of measures as used in the publications of the United States Govern-

ment. All foreign statistics are given in this work in metric weights, and the United States products are given in the metric system as well as in the customary weights. . . .

"The advertising pages of this book will well repay the careful perusal and study of every reader who wishes to be well informed upon the present condition of the mineral industry. They give an admirable and practical insight into the present state of the mining and metallurgical arts, for in them nearly every manufacturer or dealer of note in this country advertises the machines, appliances, and processes which are now in vogue, or which it is sought to introduce, while the names and qualifications of the most eminent members of the engineering professions indicate the importance and directions of modern mining and metallurgy. These advertising pages are no less important to those who desire a clear knowledge of the means by which this country has come to be far the most important producer of minerals and metals, than to him who wishes to know where to get that full and reliable information concerning the values of properties, machinery, processes, and products which should precede the investment of capital."

Had any doubt existed as to the utility and even absolute need of such a work as this, it would have been quickly dispelled by the prompt and enthusiastic recognition of its value and the unstinted and unanimous words of praise which welcomed in every part of the world the first volume of THE MINERAL INDUSTRY, ITS STATISTICS, TECHNOLOGY AND TRADE. It is not too much to say that probably no other technical book was ever so universally praised, as is shown in the brief extracts given on another page from some of the thousands of letters received, and doubtless never before was a technical book sold in so large numbers within so short a time. These results are extremely gratifying not alone from a business standpoint, but chiefly because they constitute a flattering evidence of the value of the work as a whole, and of the ability of the many specialists who contributed to its pages.

This success has increased the obligation we are under to the great captains of the industry throughout the world who have, with uniform courtesy and unlimited confidence, furnished the data which alone have permitted the compilation and prompt publication of these valuable statistical volumes.

From the very first the amount of useful material grew so rapidly with the plans for the work that it quickly became evident that the book must become larger and more costly than anticipated. The original object has, however, been kept in view of placing it within the reach of all.

The importance of collecting in this volume, as far as possible, the existing statistics of production, imports, exports, and consumption of the various minerals and metals in every country, and the large space devoted to this and to the description of the best existing practice in the chief departments of metallurgy and chemical technology, have crowded over into the current issues of the *Engineering and Mining Journal* and into succeeding volumes of this book much valuable information, and retarded the issue of this book beyond the date at which it is expected future volumes will appear.

The data collected in these two volumes present already a good foundation on which to commence an intelligent study of the industry and of the conditions

which affect it, and we earnestly invite the co-operation in this work of all who possess further facts which may be of use in it.

This introduction may be appropriately ended with the following closing paragraph of the preface to the first volume:

"No one can appreciate more fully than the statistician himself the limits and shortcomings which are inseparable from all statistical work of this character. As further facts come to light and a higher degree of accuracy rewards our continuous efforts to render these volumes trustworthy, corrections will be made in the statistics should errors of importance be found. He is but a dishonest statistician who retains known important erroneous statements in order that the public, in its ignorance, may believe, from the absence of corrections, that his figures are accurate. Readers of this book are therefore earnestly requested to notify its editor of any errors or omissions which may be found in it, in order that corrections may be made in subsequent volumes, and suggestions which may render future volumes more valuable will be gratefully received."

RICHARD P. ROTHWELL.

PREFACE TO VOLUME III.

THERE is now no need of introducing THE MINERAL INDUSTRY, ITS STATISTICS, TECHNOLOGY AND TRADE. The two volumes which have already appeared have been received, in every part of the world, with such hearty words of appreciation and approval, as probably no other work devoted to the industry has ever received.

The intention in preparing this work has been to collect and put in convenient form all the reliable statistics of the mineral industry of the world; to collect more promptly and more accurately than had hitherto been done the mineral statistics of the United States; and to photograph, as it were, the condition of the industry from year to year, bringing out into boldest relief that information which has the greatest practical value in the development of the industry and which is not easily accessible. The accumulation of the necessary data concerning the past, and the elucidation of the conditions which affect the growth and well-being of a great industry, constitute an enormous undertaking. How well it is succeeding, and how far it has progressed, these three volumes tell.

This work is above all things designed to be of actual value to the practitioner; to afford those engaged in mining, metallurgy and industrial chemistry a safe and authoritative guide which will keep them informed as to what is being done, and how it is done, in each department of the industry throughout the world.

Accurate statistics, trustworthy up-to-date technical and trade information, promptly furnished, are not only of great value to those engaged in any industry—they are absolutely indispensable for success in these days of strong competition, when enterprise, intelligence and skill guide the armies of industry in the world-wide struggle for supremacy, if not for existence. Success is no longer given to brute force; it is knowledge alone that renders its possessor invincible, and that crowns his efforts with fruition.

RICHARD P. ROTHWELL.

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NOTE.—The Table of Contents of Vols. I. and II. of THE MINERAL INDUSTRY will be found on pages 749, *et seq.*, of the present volume.

TABLES FOR CONVERTING UNITED STATES WEIGHTS AND MEASURES TO METRIC.

Linear.					Capacity.							
Inches to Millimeters.	Feet to Meters.	Yards to Meters.	Miles to Kilometers.		Drams to Cubic Centimeters.	Ounces to Milliliters.	Quarts to Liters.	Gallons to Liters.	Cubic Inches to Cubic Centimeters.	Cubic Feet to Cubic Meters.	Cubic Yards to Cubic Meters.	Bushels to Hectoliters.
25.4000	0.304801	0.914402	1.60935	= 1 =	3.70	29.57	0.94636	3.78544	16.387	0.02832	0.765	0.35242
50.8001	0.609601	1.828804	3.21869	= 2 =	7.39	59.15	1.89272	7.57088	32.774	0.05663	1.529	0.70485
76.2001	0.914402	2.743205	4.82804	= 3 =	11.09	88.72	2.83908	11.35632	49.161	0.08495	2.294	1.05727
101.6002	1.219202	3.657607	6.43739	= 4 =	14.79	118.30	3.78544	15.14176	65.549	0.11327	3.058	1.40969
127.0002	1.524003	4.572009	8.04674	= 5 =	18.48	147.87	4.73180	18.92720	81.936	0.14158	3.823	1.76211
152.4003	1.828804	5.486411	9.65608	= 6 =	22.18	177.44	5.67816	22.71264	98.323	0.16990	4.587	2.11454
177.8003	2.133604	6.400813	11.26543	= 7 =	25.88	207.02	6.62452	26.49808	114.710	0.19822	5.352	2.46696
203.2004	2.438405	7.315215	12.87478	= 8 =	29.57	236.59	7.57088	30.28352	131.097	0.22654	6.116	2.81938
228.6004	2.743205	8.229616	14.48412	= 9 =	33.28	266.16	8.51724	34.06896	147.484	0.25485	6.881	3.17181

Square.					Weight.				
Square Inches to Square Centimeters.	Square Feet to Square Decimeters.	Square Yards to Square Meters.	Acres to Hectaers.		Grains to Milligrams.	Avoirdupois Ounces to Grams.	Avoirdupois Pounds to Kilograms.	Troy Ounces to Grams.	
6.452	9.290	0.836	0.4047	= 1 =	64.7989	28.3495	0.45359	31.10348	
12.903	18.581	1.672	0.8094	= 2 =	129.5978	56.6991	0.90719	62.20696	
19.355	27.871	2.508	1.2141	= 3 =	194.3968	85.0486	1.36078	93.31044	
25.807	37.161	3.344	1.6187	= 4 =	259.1957	113.3981	1.81437	124.41392	
32.258	46.452	4.181	2.0234	= 5 =	323.9946	141.7476	2.26796	155.51740	
38.710	55.742	5.017	2.4281	= 6 =	388.7935	170.0972	2.72156	186.62089	
45.161	65.032	5.853	2.8328	= 7 =	453.5924	198.4467	3.17515	217.72437	
51.613	74.323	6.689	3.2375	= 8 =	518.3914	226.7962	3.62874	248.82785	
58.065	83.613	7.525	3.6422	= 9 =	583.1903	255.1457	4.08233	279.93133	

1 chain = 20.1169 meters.
1 square mile = 259 hectaers.
1 fathom = 1.829 meters.
1 nautical mile = 1853.27 meters.
1 foot=0.304801 meter, 9.4840158 log.
1 avoir. pound = 453.5924277 gram.
15432.35639 grains = 1 kilogram.

TABLES FOR CONVERTING METRIC TO UNITED STATES WEIGHTS AND MEASURES.

Linear.					Capacity.							
Meters to Inches.	Meters to Feet.	Meters to Yards.	Kilometers to Miles.		Milliliters or Cubic Centiliters to Fluid Drams.	Centiliters to Fluid Ounces.	Liters to Quarts.	Dekaliters to Gallons.	Hektoliters to Bushels.	Cubic Centimeters to Cubic Inches.	Cubic Meters to Cubic Feet.	Cubic Meters to Cubic Yards.
39.3700	3.28083	1.093611	0.62137	= 1 =	0.27	0.338	1.0567	2.6417	2.8375	0.0610	35.314	1.308
78.7400	6.56167	2 187222	1.24274	= 2 =	0.54	0.676	2.1134	5.2834	5.6750	0.1220	70.629	2.616
118.1100	9.84250	3.280833	1.86411	= 3 =	0.81	1.014	3.1700	7.9251	8.5125	0.1831	105.943	3.924
157.4800	13.12333	4.374444	2.48548	= 4 =	1.08	1.352	4.2267	10.5668	11 3500	0.2441	141.258	5.232
196.8500	16.40417	5 468056	3.10685	= 5 =	1.35	1.691	5.2834	13.2085	14.1875	0.3051	176.572	6.540
236.2200	19 68500	6 561667	3.72822	= 6 =	1.62	2.029	6.3401	15.8502	17.0250	0.3661	211.887	7.848
275 5900	22.96533	7.655278	4.34959	= 7 =	1.89	2.368	7.3968	18.4919	19.8625	0.4272	247.201	9.156
314.9600	26.24667	8 748889	4.97096	= 8 =	2.16	2.706	8.4534	21.1336	22.7000	0.4882	282.516	10.464
354.3300	29.52750	9.842500	5.59233	= 9 =	2.43	3.043	9.5101	23.7753	25.5375	0.5492	317.830	11.771

Square.					Weight.			
Square Centimeters to Square Inches.	Square Meters to Square Feet.	Square Meters to Square Yards.	Hectares to Acres.		Kilograms to Grains.	Hectograms to Ounces Avoirdupois.	Kilograms to Pounds Avoirdupois.	Grams to Ounces Troy.
0.1550	10.764	1.196	2.471	= 1 =	15432.36	3.5274	2.20462	0.03215
0.3100	21.528	2.392	4.942	= 2 =	30864.71	7.0548	4.40924	0.06430
0.4650	32.292	3.588	7.413	= 3 =	46297.07	10.5822	6.61386	0.09645
0.6200	43.055	4.784	9.884	= 4 =	61729.43	14.1096	8.81849	0.12860
0.7750	53.819	5.980	12.355	= 5 =	77161.78	17.6370	11.02311	0.16075
0.9350	64.583	7.176	14.826	= 6 =	92594.14	21.1644	13.22773	0.19290
1.0850	75.347	8.372	17.297	= 7 =	108026 49	24 6918	15.43235	0.22505
1.2400	86.111	9.568	19.768	= 8 =	123458.85	28.2192	17.63697	0.25721
1.3950	96.874	10.764	22.2	= 9 =	138891.21	31.7466	19.84159	0.28936

The only material standard of customary length authorized by the U. S. Government is the Troughton scale, whose length at 59°.62 Fahr. conforms to the British standard. The yard in use in the United States is therefore equal to the British yard.

The only authorized material standard of customary weight is the Troy pound of the Mint. It is of brass

of unknown density, and therefore not suitable for a standard of mass. It was derived from the British standard Troy pound of 1758 by direct comparison. The British avoirdupois pound was also derived from the latter, and contains 7000 grains Troy.

The grain Troy is therefore the same as the grain avoirdupois, and the pound avoirdupois in use in the United States is equal to the British pound avoirdupois.

The British gallon = 4.54346 liters.

The British bushel = 36.3477 liters.

By the concurrent action of the principal Governments of the world an International Bureau of Weights and Measures has been established near Paris. Under the direction of the International Committee, two ingots were cast of pure platinum-iridium in the proportion of 9 parts of the former to 1 of the latter metal. From one of these a certain number of kilograms were prepared, from the other a definite number of meter bars. These standards of weight and length were intercompared, without preference, and certain ones were selected as International prototype standards. The others were distributed by lot to the different Governments and are called National prototype standards.

The metric system was legalized in the United States in 1866.

The International Standard Meter is derived from the Mètre des Archives, and its length is defined by the distance between two lines at 0° Centigrade, on a platinum-iridium bar deposited at the International Bureau of Weights and Measures.

The International Standard Kilogram is a mass of platinum-iridium deposited at the same place, and its weight *in vacuo* is the same as that of the Kilogramme des Archives.

The liter is equal to a cubic decimeter of water, and it is measured by the quantity of distilled water which, at its maximum density, will counterpoise the standard kilogram in a vacuum, the volume of such a quantity of water being, as nearly as has been ascertained, equal to a cubic decimeter.

Long ton: 2240 lbs. avoirdupois	= 1016	kilo.	Barrel of petroleum	= 42 gal. = 1.59	hec.
Short ton: 2000 " "	= 907.2	"	" " salt	= 280 lbs. = 127	kilo.
Pound avoirdupois	= 453.6	grams.	" " lime	= 200 " = 90.720	"
Flask of mercury = 76½ lbs. avoir.	= 34.700	kilo.	" " natural cement	= 300 = 136.080	"
Troy ounce	= 31.104	grams.	" " Portland cement	= 400 " = 181.440	"
Gallon	= 3.785	litres.	Gold coining value per oz. c.	$20.6718 = $0.6646	per gram.
			Silver " " " " c.	$1.9229 = $0.04157	" "

OFFICIAL UNITED STATES VALUES OF FOREIGN COINS, APRIL 1, 1894.

Country.	Standard.	Unit.	Value in U. S. Gold.	Coins.
			cts.	
Argentina	Both	Peso	96.5	Gold: argentine ($4.824) and ½ argentine. Silver: peso and divisions.
Austria-Hungary	Gold	Crown	20.3	Gold: former system—4 florins ($1.929), 8 florins ($3.858), ducat ($2.287), and 4 ducats ($9.158). Silver: 1 and 2 florins. Present system—Gold: 20 crowns ($4.052) and 10 crowns ($2.026).
Belgium	Both	Franc	19.3	Gold: 10 and 20 francs. Silver: 5 francs.
Bolivia	Silver	Boliviano	46.3	Silver: boliviano and divisions.
Brazil	Gold	Milreis	54.6	Gold: 5, 10, and 20 milreis. Silver: ½, 1, and 2 milreis.
Canada	Gold	Dollar	100	
Central America: Costa Rica, Guatemala, Honduras, Nicaragua, Salvador	Silver	Peso	46.5	Silver: peso and divisions.
Chile	Both	Peso	91.2	Gold: escudo ($1.824), doubloon ($4.561), and condor ($9.123). Silver: peso and divisions.
China	Silver	Tael ‡	68.6 / 76.5	
Colombia	Silver	Peso	46.5	Gold: condor ($9.647) and double-condor. Silver: peso.
Cuba	Both	Peso	92.6	Gold: doubloon ($5.017). Silver: peso.
Denmark	Gold	Crown	26.8	Gold: 10 and 20 crowns.
Ecuador	Silver	Sucre	46.5	Gold: condor ($9.647) and double-condor. Silver: sucre & divisions.
Egypt	Gold	Pound	494.3	Gold: pound (100 piasters), 5, 10, 20, and 50 piasters. Silver: 1, 2, 5, 10, and 20 piasters.
Finland	Gold	Mark	19.3	Gold: 20 marks ($3.859), 10 marks ($1.93).
France	Both	Franc	19.3	Gold: 5, 10, 20, 50, and 100 francs. Silver: 5 francs.
German Empire	Gold	Mark	23.8	Gold: 5, 10, and 20 marks.
Great Britain	Gold	Pound	486.65	Gold: sovereign (pound sterling) and ½ sovereign.
Greece	Both	Drachma	19.3	Gold: 5, 10, 20, 50, and 100 drachmas. Silver: 5 drachmas.
Haiti	Both	Gourde	96.5	Silver: gourde.
India	Silver	Rupee	22.1	Gold: mohur ($7.105). Silver: rupee and divisions.
Italy	Both	Lira	19.3	Gold: 5, 10, 20, 50, and 100 lire. Silver: 5 lire.
Japan	Both*	Yen	99.7 / 50.1	Gold: 1, 2, 5, 10, and 20 yen. Silver: yen.
Liberia	Gold	Dollar	100	
Mexico	Silver	Dollar	50.5	Gold: dollar ($0.983), 2½, 5, 10, and 20 dollars. Silver: dollar (or peso) and divisions.
Netherlands	Both	Florin	40.2	Gold: 10 florins. Silver: ½, 1, and 2½ florins.
Newfoundland	Gold	Dollar	101.4	Gold: 2 dollars ($2.027).
Norway	Gold	Crown	26.8	Gold: 10 and 20 crowns.
Peru	Silver	Sol	46.5	Silver: sol and divisions.
Portugal	Gold	Milreis	108	Gold: 1, 2, 5, and 10 milreis.
Russia	Silver	Ruble ‖	77.2 / 37.2	Gold: imperial ($7.718) and ½ imperial† ($3.86). Silver: ¼, ½, and 1 ruble.
Spain	Both	Peseta	19.3	Gold: 25 pesetas. Silver: 5 pesetas.
Sweden	Gold	Crown	26.8	Gold: 10 and 20 crowns.
Switzerland	Both	Franc	19.3	Gold: 5, 10, 20, 50, and 100 francs. Silver: 5 francs.
Tripoli	Silver	Mahbub §	41.9	
Turkey	Gold	Piaster	04.4	Gold: 25, 50, 100, 250, and 500 piasters.
Venezuela	Both	Bolivar	19.3	Gold: 5, 10, 20, 50, and 100 bolivars. Silver: 5 bolivars.

*Gold the nominal standard. Silver practically the standard. †Coined since January 1, 1886. Old half-imperial = $3.986. ‡Shanghai and Haikwan (Customs). §Of 20 piasters. ‖Silver the nominal standard. Paper the actual currency, the depreciation of which is measured by the gold standard.

RICHARD P. ROTHWELL.

CONTRIBUTORS.

It would be impossible to name here all who have aided us in the collection of statistics and other information for the present volume; but we have given in the following pages brief biographies of those who have contributed special articles on technical and other topics, in order that readers may appreciate the high professional standing of those who have assisted in the work. In a number of cases these sketches are accompanied by portraits.

While space prevents us from further extending the list, we desire to express our grateful appreciation of the ready assistance and co-operation we have received from thousands of miners and other producers, and of State and other officials, in the collection of statistics of mineral production and other information for the present volume. It is this general appreciation of the value of the work, this hearty co-operation that have enabled us to make the statistics complete and to bring the figures up to the latest dates; and we wish once more, not only for ourselves, but on behalf of all who are interested in the great industry which this volume represents, to thank those who have aided us in making it a faithful history of a year's progress of the industry

The sketches of the special contributors are given below in alphabetical order.

Acheson, Edward G., born in 1856, served four years on an engineer corps engaged in railroad construction, and then accepted a position with the United Pipe Lines Company. In 1880 he held a position with the distinguished electrician T. A. Edison, at Menlo Park, N. J. The following year he was sent to Europe as assistant engineer, and constructed the first incandescent light plants in Holland and Italy. Returning to the United States in 1884, he spent two years in experimental work and then became electrician to the Standard Underground Cable Company of Pittsburg. In 1890 he organized the Monongahela Electric Light Company and became its president. During the following year some experiments led to the production of carborundum, and the Carborundum Company was organized with Mr. Acheson as its president. Mr. Acheson has contributed many valuable papers to technical literature and wrote for this volume, as for Volume II., the article on "Carborundum."

Adams, William H., was born in Michigan in 1843. At the close of the war he went to Canada and took charge of the Hartford copper mine and smelting works in the Capelton district, Quebec. In 1883 he took charge of the Arminius mine in Louisa County, Virginia, and has devoted his attention chiefly to perfecting furnaces for roasting pyrites and apparatus used in acid making and copper extraction, on which subjects he is eminent authority, having constructed and managed the first four works erected in America for these purposes. Mr. Adams is a well-known contributor to the transactions of the various engineering societies of which he is a member, and to the *Engineering and Mining Journal*. Mr. Adams has contributed to this third volume the article on "Improvements in the Manufacture of Sulphuric Acid."

Blandy, John F, born in Newark, Del., 1833, studied at schools in his native place and at Delaware College. At 18 years of age he was attached to an engineer corps on the Philadelphia and Reading Railroad, but after a year's service went to Germany and studied there three years. From 1855 to 1863 he was engaged in the Lake Superior copper region and became

thoroughly familiar with every section of it. In 1860 he published a paper on the region in *Silliman's Journal*. In 1863 he became connected with the Little Schuylkill Railroad and Coal Company, and managed that company's affairs until it was leased to the Reading in 1868. After managing various properties in the Pennsylvania bituminous region, he went to Arizona in 1880, and has since resided in that territory, with the exception of a short time spent in California. He has done much engineering work there, and was territorial Geologist from April, 1889, to November, 1890, resigning because the appropriation was too small to permit any real work. Mr. Blandy has profound faith in the resources and future of Arizona, and has contributed many notes in relation to its mines and minerals.

BLUE, ARCHIBALD, was born in 1840 in Oxford, Ontario, Canada. After engaging for some years as a teacher, he entered the field of journalism, which he followed for nearly fourteen years. In 1881 he was appointed to organize and take charge of a Bureau of Industrial Statistics in connection with the Department of Agriculture, and in 1884 was made deputy head of the department. During 1889–90 he served as member and secretary of the Royal Commission appointed to inquire into and report upon the mineral resources of Ontario, and in 1891 resigned his office to become Director of the Bureau of Mines of Ontario, with his offices in Toronto. Mr. Blue has contributed valuable statistics of Ontario to this volume.

BOTELLA Y HORNOS, FEDRICO, recently Inspector General of the Minings Corps and at present Chief of the Bureau of Mining Statistics at Madrid, Spain, is a mining engineer of high reputation in Spain. He is a member of the Academy of Sciences and author of several papers and other works on technical subjects. Señor Botella y Hornos has very kindly furnished the latest statistics of the mineral production of Spain.

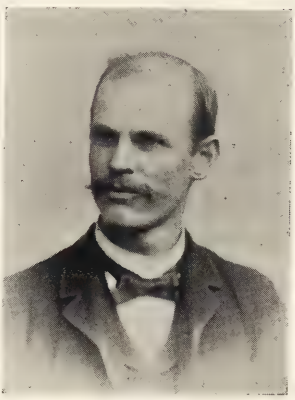
BREWER, WILLIAM M., is a native of England, but came to America at an early age. He was for a number of years engaged in mining in the West, having held positions with several different mining companies in South Dakota and other Western States. For some years past he has been occupied in the South, and has been working for the Alabama, Georgia, and other State Geological Surveys. He has been a regular correspondent of the *Engineering and Mining Journal* for several years, and has also written for other periodicals. In the present volume Mr. Brewer contributes the articles on "Alabama" and "Georgia," besides furnishing information on bauxite, iron ores and other topics.

BROWN, LUCIUS P., a native of Tennessee, graduated in chemistry at the University of Virginia, afterward taking a post-graduate course there for a year. He then held the position of acting chemist to the State Experiment Station of Tennessee for nearly a year, but resigned from it and went to farming; after some experience in that line he went to work analyzing and prospecting the newly-discovered phosphate fields. He was located at first at Ætna, Tenn., leasing the laboratory of the Southern Iron Company, but a few months since formed a partnership, which still exists, with Mr. C. G. Memminger. He has given much time to the subject of agricultural chemistry and fertilizers, especially the latter, and has been connected with the phosphate industry in Tennessee from the first opening of the deposits. Mr. Brown has contributed the article on "Phosphates of Tennessee" in the present volume.

BROWN, ROBERT GILMAN, is a graduate of Darmouth College, Hanover, N.H., and of Columbia College School of Mines. After serving some time as assistant instructor in the last named institution, Mr. Brown established himself at Butte, Mont., and since 1890 has been engaged as mining engineer and superintendent of mines for W. A. Clark, in Butte and vicinity. Mr. Brown contributed to the present volume the excellent articles on the "Practice in the Mines of Butte" and on the work done in those mines during the past year. He was recently appointed manager of the Standard Consolidated Mining Company, at Bodie, Cal.

BRYAN, L. W., born in 1853, in Luzerne County, Pennsylvania. In 1876 he went to Arkansas, and has since been prominently identified with the development of the coal industry in that and other States. He opened the Onita mines near Russellville, then the Coal Hill and Spadra Mines. In 1886 he laid out and purchased the Jenny Lind coal field for Mr. Jay Gould. The following year he became superintendent for the Texas Coal Company, and remained with it until appointed United States Mine Inspector for Indian Territory. Mr. Bryan's duties have led him into the coal fields of Iowa, Missouri, and Kansas, where he has purchased and developed many valuable mines, and also in the coal fields of Arkansas and Indian Territory.

SOME OF THE CONTRIBUTORS TO THE MINERAL INDUSTRY.



EDWARD C. ACHESON.

WILLIAM H. ADAMS.

JOHN F. BLANDY.

ARCHIBALD BLUE.

WILLIAM M. BREWER.

ROBERT GILMAN BROWN.

LUCIUS P. BROWNE.

CHANNING, J. PARKE, was born in New York City, and graduated from the Columbia College School of Mines in 1883. After spending some time as mining engineer at the Osceola and Tamarack copper mines he was appointed deputy commissioner of mineral statistics for Michigan and prepared that portion of the State report relating to copper mines. He was then engaged for a time in examining gold properties and establishing steamboat navigation in Honduras; on his return to the United States he was appointed inspector of mines on the Gogebic Iron Range in Michigan, holding that position for two and a half years. Since then he has been engaged as manager of the East New York iron mine in Michigan, in charge of exploration work for the Chicago, Milwaukee & St. Paul Railroad Company along its new line through the iron range, and as assistant to the Superintendant of the Calumet & Hecla Copper Mining Company. Mr. Channing took a prominent part in the establishment of the Michigan Mining School at Houghton and in the organization of the Lake Superior Mining Institute. He has been an occasional contributor to the *Engineering and Mining Journal.* He contributed to the present volume the exhaustive article on "Iron Ore Mining in the Lake Superior District."

ENEQUIST, ERIK, was born in 1864 in Gotland, Sweden, and graduated from the Polytechnic School at Stockholm in 1885. In the same year he came to the United States and was employed as chemist and superintendent of the extensive works of L. Feuchtwanger in New York. Since 1891 he has conducted business as consulting chemist and dealer in chemicals, devoting his time chiefly to the manufacture of carbonic acid, sulphate of soda and similar chemicals, for which purpose he recently established a factory in Jersey City. Mr. Enequist is the inventor of a number of improvements in chemical processes, especially of the method of making carbonic acid by means of magnesite and acid sulphate of soda. He has written for this volume the article on "Metallic Oxides, their Uses and Preparation."

ENEQUIST, JOHN T., was born in 1858 in Gotland, Sweden, and graduated from the Polytechnic School at Stockholm in 1880. He soon after came to the United States, where he was for a number of years engaged as chemist and afterward superintendent of the Cochran Chemical Company of Boston. In 1891 he left Boston and came to New York, where he was first employed with the Phœnix Chemical Works and afterward with the Martin Kalbfleisch Chemical Company. Since 1894 he has been in business for himself as consulting chemist and chemical engineer in New York. Mr. Enequist has written for THE MINERAL INDUSTRY the very full and interesting monograph on "Alum and Sulphate of Alumina," the first complete account of the manufacture of those important substances which has ever been published.

FORD, WORTHINGTON C., to whom we are indebted for statistics of the imports, exports, etc., of the United States, used in the compilation of the tables accompanying this volume, is now Chief of the Bureau of Statistics in the Treasury Department of the United States, in which he has introduced many notable improvements since his appointment to the position. Mr. Ford has had long and valuable experience in statistical work, and for several years filled the office of Chief of the Bureau of Statistics in the State Department, where his work was worthy of the highest commendation. The excellent statistical reports he now publishes are extremely valuable documents.

GILPIN, EDWIN, JR., born in 1850 in Halifax, N. S. Mr. Gilpin is the son of the Dean of Nova Scotia, and grandson of Judge Haliburton, so widely known under his *nom de plume* "Sam Slick." In 1871 he graduated from King's College, Windsor, N. S., and then served his time at the Albion mines, Pictou County. After this he spent some time in England at the collieries of Sir George Elliott and others. Upon his return to Nova Scotia he engaged in professional work and later succeeded Sir William Dawson in examining and mapping the iron ores of Pictou County. In 1879 he was appointed Inspector of Crown Mines in Nova Scotia; in 1886, Deputy Commissioner of Public Works and Mines. Mr. Gilpin has contributed numerous papers and reports upon the mining and geological interests of Nova Scotia to the technical periodicals of England and America, and has contributed the mineral statistics of Nova Scotia for 1894 to this volume of THE MINERAL INDUSTRY.

HARZE, EMILE, born in 1835, at Liége, Belgium ; studied at the Ecole des Mines attached to the university of his native place. In 1858 he entered the State Mining Corps and successively

occupied important government positions at Mons and Liége, and in 1879 was made Director-General of the Central Administration at Brussels. In 1890 he was one of the Belgium representatives at the Berlin Labor Conference. Mr. Harzé is a member of numerous technical and scientific societies and is on the committees of a number of commissions, among them the *Conseil Supérieur du Travail.* He has published a great number of valuable monographs and is one of the highest authorities in Europe on mine ventilation, statistics, and questions affecting labor. To the present volume Mr. Harzé has contributed notes on Belgium coal mining and the statistics of the Belgium industry.

HOBART, FREDERICK, A. B. and A. M. of the College of the City of New York. Mr. Hobart has been connected with the Jersey City Locomotive Works; Bullock Machine Company, Jersey City; Wrigley Machine Works, Newark, N. J.; Grant Locomotive Works, Paterson, N. J.; has been assistant editor of the *Railroad Gazette,* associate editor *Railroad and Engineering Journal,* assistant editor *Engineering and Mining Journal,* a contributor to various technical periodicals, and is the translator of "Notes on Steam Hammers" and "Economies in the Combustion of Fuel." Mr. Hobart has contributed to this third volume the articles on "Coal," "Iron" and "Lead," and several of the shorter articles. He has also performed a large share of the general work of preparing the volume, and has made for this, as for Volumes I. and II., the very full index.

HOFMAN, H. O., was born in Heidelberg, Germany, and received his early training in that city taking a course in mathematics, chemistry and geology in the University. From Heidelberg he proceeded to the Royal Prussian School of Mines at Clausthal, where he graduated both in mining, engineering and metallurgy. He was then appointed chemist and assistant at the government refining and smelting works at Lautenthal in the Harz, where he was employed in carrying out a number of experiments. In 1881 he came to the United States and was employed successively at Mine La Motte in Missouri, at the Kansas City Smelting and Refining Works, and as metallurgist of the Delaware Lead Company, in Philadelphia. When the last named works were closed he went to Colorado, and after running the Rico smelter for a short time was engaged with Mr. Russell in a study of amalgamation and lixiviation of silver ores at the Ontario Mill in Park City, Utah. After a short time spent in charge of a smelter in Mexico he was appointed assistant to Professor Richards at the Massachusetts Institute of Technology in Boston; from there he went to the School of Mines of South Dakota, where he remained until called back to the Massachusetts Institute of Technology to the professorship which he now holds. Dr. Hofman's chief work is his admirable one on "The Metallurgy of Lead," but he has published a number of shorter monographs and pamphlets, including "Gold Milling in the Black Hills," "The Assay of Tin Ores," "The Concentration Works at Lautenthal," etc. He has contributed to the present volume a paper on "The Recent Improvements in the Metallurgy of Lead." Dr. Hofman is now universally recognized as the highest living authority on this subject.

HOLIBAUGH, J. R., mining engineer of Joplin, Mo., who is exceptionally familiar with the zinc-lead industry of Missouri and Kansas, has furnished much very valuable information which appears in the articles in this volume devoted to that industry. He has written also the article on the "Zinc Mines of Missouri and Kansas."

HOPKINS, T. C., born in 1861, in Pennsylvania. In 1883 he entered De Pauw University at Greencastle, Ind., graduated in 1887, and took the degree of M. S. in 1890. For some time he had charge of the department of chemistry at this university. During 1889-90 Mr. Hopkins was assistant on the Geological Survey of Arkansas. In 1893 he was engaged as instructor in geology in the mining department at the State College, Pennsylvania. His published writings consist of valuable contributions to the Geological Survey Reports of Arkansas and papers read before various technical and scientific societies. To the present volume Mr. Hopkins has contributed articles on "Bedford Limestone" and on "Marble."

INGALL, ELFRIC DREW, born in 1858, at Greenhithe, Kent, England. Studied at the Royal School of Mines, London, and afterward in the mining districts of Cornwall and Wales. In 1880 he was sent to Canada to examine mining properties on Lake Superior, and afterward became manager of a company there. He subsequently spent some time in Wyoming studying

SOME OF THE CONTRIBUTORS TO THE MINERAL INDUSTRY.

J. PARKE CHANNING.

ERIK ENEQUIST.

JOHN T. ENEQUIST.

EDWIN GILPIN, JR.

EMILE HARZÉ.

FREDERICK HOBART.

H. O. HOFMAN.

copper deposits, after which he joined the Canadian Geological Survey and has remained its mining engineer in charge of the division of mineral statistics and mines since 1884. Mr. Ingall's work on the silver-bearing veins of the Thunder Bay district, the apatite deposits of Quebec, and the mineral developments around the Canadian shores of Lake Superior, are well known, and with them the valuable data published each year by his division of the survey.

JANIN, LOUIS, JR., is a mining engineer and metallurgist of thorough training and wide and varied experience in many parts of the United States, Mexico, South America and Australia. He has contributed various valuable technical monographs to different papers, and for some time was assistant editor of the *Engineering and Mining Journal.* For over a year past Mr. Janin has been engaged as an expert in connection with the cyanide process of gold extraction, and is now in Australia on business connected with the introduction of that process and other improvements in the gold mills there. Mr. Janin has contributed to the present volume the article on the "Amalgamation of Gold Ores," which is believed to be the most complete monograph on that subject yet published.

JONES, DAVID PHILLIPS, was born in Philadelphia. In 1858, when but a youth, he was appointed one of the principal examiners of the Utah Public Surveys. He was afterward appointed resident engineer of the Surveyor-General's office in Salt Lake City. At the breaking out of the war he entered the Engineer Corps of the United States Navy and continued in active service in the navy until June, 1892, when he was placed upon the retired list. He was stationed at the United States Naval Academy as an instructor in engineering for five years, and was one of those who arranged the course in steam engineering. During an extended leave of absence, Mr. Jones was engineer of the St. Louis & Southeastern Railway. He was afterward president of the West Kansas Construction Company and built several lines of railroad in Kansas. In 1884 he opened the Bandera Flagstone Quarries, near Ft. Scott, Kan., and is regarded as an authority in quarrying flagstone. During Mr. Jones' connection with the active list of the Engineer Corps of the Navy, he was frequently on duty at the Bureau of Steam Engineering and was engaged upon the designing of the machinery for the new cruisers *Boston* and *Atlanta*. At present he is engaged in Chicago as consulting engineer, while still managing the quarries mentioned. A description of the Bandera quarries, and of the methods and appliances used there, is Mr. Jones' contribution to this volume.

KEYES, DR. CHARLES ROLLIN, was born in Des Moines, Iowa, in 1864. He studied in Des Moines and at the Iowa State Academy at Iowa City, graduating in 1887. His studies in the university were chiefly engineering, chemistry, geology and the modern languages. After graduating he spent some time in assisting Dr. Charles Wachsmuth in preparing a number of papers on zoology and geology. He then took a course at the Johns Hopkins University in Baltimore and commenced some original investigations which resulted in the preparation of several valuable papers. When the Iowa State Geological Survey was instituted Dr. Keyes was appointed Assistant State Geologist and had the principal share of the work and of the preparation of the several excellent reports issued by the survey. In 1894 he was called upon to take charge of the Missouri Bureau of Geology and Mines and undertook the work of completing the organization of that bureau. Dr. Keyes is a prolific author, having published many monographs and articles, the most important of which are the three volumes of the Iowa Geological Survey upon the geological formations of the State, the Coal Deposits and the Gypsum Deposits; and the "Report on the Paleontology of Missouri." Dr. Keyes has contributed to the present volume much valuable information relating to the geology and mineral industry of Missouri.

KNIGHT, WILBUR C., was born in Illinois in 1858, and moved to the western frontier when a boy. Educated at the University of Nebraska, taking special work in geology and chemistry. Since graduation he has been the first Assistant Territorial Geologist of Wyoming for two years; for six years superintendent and general manager of mining corporations in Wyoming and Colorado. In 1893 he was called to the chair of mining in the School of Mines, University of Wyoming, and in 1894 was elected to the chair of geology and mining in the same school. Mr. Knight contributes articles on the coal and other minerals of Wyoming.

LANDIS, HARRY KINZER, born in Pennsylvania in 1865. Received the degrees of Bachelor

of Science and Engineer of Mines from Lehigh University. He was employed by the Penn, sylvania Steel Company at its steel plant in Steelton, Penn., acted as assistant to Mr. John Fritz, superintendent and engineer of the Bethlehem Iron Company, in the construction of its ordnance works, and subsequently as engineer for the Lehigh Zinc and Iron Company at Bethlehem, Penn. In 1893 he was chosen by the State Board of Curators of the University of Missouri to occupy the chair of Mines and Metallurgy in the Missouri School of Mines; after resigning this position and doing some professional work in the South, he has given valuable assistance in the collection of the mineral statistics for this volume of THE MINERAL INDUSTRY. He is a member of the American Institute of Mining Engineers, the American Chemical Society, etc.

LANGELOTH, J., president of the American Metal Company, and vice-president of the Balbach Smelting and Refining Company, has furnished very valuable information concerning the trade department of the mineral industry in which his company is so prominent a factor, and has, with unfailing courtesy and good will, aided in many ways our efforts to secure full and reliable information.

LEFEVRE, EDWIN, born in Colon, Republic of Colombia, in 1870. Studied mining engineering at Lehigh Univerity, Bethlehem, Penn. He has been engaged in journalism for several years, and has contributed to numerous newspapers and literary periodicals in the United States and South America. Since 1890 he has been a member of the editorial staff of the *Engineering and Mining Journal*. Mr. Lefevre has contributed articles upon the commercial department of the industry, the chemical and mining stock markets, with which his duties on the *Engineering and Mining Journal* have rendered him very familiar.

LEVAT, DAVID, born in 1855, at Montpellier, France, studied in the Ecolé Polytechnique and the School of Mines of Paris, 1877, graduating a mining engineer in 1880. After four years experience of mining in the copper mines of Montecateni in Tuscany and in Greece and Algeria, he was appointed in 1885 general manager of the Societé du Nickel and remained till the end of 1889 at the head of the company's works. Mr. Levat there acquired a large experience in the metallurgy of nickel and he has written various monographs on this subject. As consulting engineer of various companies Mr. Levat has visited and reported upon mines in nearly all parts of the world, especially New Caledonia, Australia and California. Since 1894 he has been largely interested in the new discoveries of phosphate deposits in Algeria and Tunis and has written for this volume the important article on the "Phosphates of Tunis and Algeria." Mr. Levat is at present engaged examining the Upper Amour gold placers in Siberia Russia.

LUNGE, GEORGE, PH. D., born in 1839, at Breslau, Silesia, Prussia. Studied at the University of Breslau, where he received the degrees of M. A. and Ph. D., and then at Heidelberg under Bunson & Kirchhoff. In 1884 he went to Great Britain, where he became connected with the coal tar and ammonia industry. A few years later Dr. Lunge took an opportunity to connect himself with the sulphuric acid and akali industry. In 1876 he left England to accept the post made vacant by the death of Emil Kopp at the Swiss Federal Polytechnic School at Zurich, where he is now professor of technological chemistry and dean of the faculty of chemistry. Dr. Lunge has contributed to technical literature some of its most important works. His "Coal Tar and Ammonia," "The Manufacture of Sulphuric Acid and Alkali," and "The Alkali-maker's Hand-book" have each passed through several editions and are standard works on these subjects. Besides these, he is a contributor to the *Engineering and Mining Journal*, has published numerous articles upon various subjects of technical chemistry in this and other periodicals, and is, in that important branch of industry, one of the highest and most widely quoted authorities. Dr. Lunge has contributed to this volume some notes on sulphuric acid manufacture in the United States, besides other information.

MERRILL, FREDERICK JAMES HAMILTON, born in New York City in 1861, graduated from Columbia College and the School of Mines. He was assistant on the Geological Survey of New Jersey 1885–87; Fellow in Geology, Columbia College, 1886–90, and Assistant State Geologist of New York 1890–93. He was appointed assistant director New York State Museum December, 1890, and director in June, 1894; he acted as director of the Scientific Exhibit of the State

SOME OF THE CONTRIBUTORS TO THE MINERAL INDUSTRY.

JOHN R. HOLIBAUGH.

T. C. HOPKINS.

ELFRIC DREW INGALL.

DAVID PHILLIP JONES.

WILBUR C. KNIGHT.

EDWIN LEFEVRE.

DAVID LEVAT.

of New York at the World's ColumbianExposition 1892–93. He has published papers on the "Geology of Long Island," and several articles in the reports of the State Geologist of New Jersey, and several bulletins of the New York State Museum. He has furnished much information on the mineral industries of New York.

NORWOOD, CHARLES J., State Inspector of Mines in Kentucky, and Curator of the Geological Department of that State. Mr. Norwood was at one time assistant on the Missouri Geological Survey, and afterward assistant on the Kentucky Geological Survey under Prof. N. S. Shaler. From 1877 to 1881 he was also Norton Professor of Natural Science in Bethel College, Russellville, Ky. For some years he was professionally engaged in various Southern and Western States, and in 1884 was appointed State Inspector of Mines for Kentucky, where he is now serving his third term. Mr. Norwood is one of the most efficient officials in this country whose duties are especially connected with the mineral industry. He has given valuable assistance in collecting promptly the coal statistics of Kentucky, and in furnishing information concerning other useful minerals of that State.

PAGE, WILLIAM NELSON, born 1855 in Campbell County, Va., and began work as a civil engineer on the Chesapeake and Ohio Railroad in 1871, and after various work on that line he successfully located and built a very difficult line up Mill Creek. In 1875–76 he was engaged in government surveys, for a double-track road from Clifton Forge to Richmond, Va., and in working up estimates on same for comparison with the James River & Kanawha Canal. From 1877 to 1881, he was in charge of the Hawks Nest Coal Mines at Ansted, W. Va., and the results were so favorable that The Iron and Steel Works Association of Virginia, Limited, was organized in London. As its general manager and financial agent, he built the Victoria furnace at Goshen, Va., supervising personally the entire construction including the mines and about 25 miles of railway. This plant was completed in 1883, in which year he resigned his connection with the Hawks Nest Coal Company in order to devote his entire time to the running of the Victoria furnace, which he operated until 1885, working iron at $150 less than the estimated cost, upon which the furnace was built. From 1885 to 1889 he was under contract with the Mount Carbon Company, Limited, to develop and operate 10,000 acres of coal land in Fayette County, W. Va., and in this connection constructed a branch line to Powellton, 202 coke ovens, and developed the mines to a large capacity. From 1889 to the present time he has been connected with the Gauley Mountain Coal Company. Mr. Page is one of the most successful Coal Mining Engineer in this country and is recognized as one of the highest authorities on the economics of the industry in which he has made a record for good and economical work.

PENHALE, MATTHEW, has been for a number of years practically engaged in mining in the United States and Canada, and has had especially long experience in the mines of Ontario and Quebec. For some years past he has been engaged in asbestos mining in Quebec, and contributed to the present volume the notes on "Asbestos in Canada."

PETERS, EDWARD DYER, JR., M. D., mining engineer and metallurgist, and the well-known author of that admirable work, "Modern Methods of Copper Smelting." Dr. Peters was born in 1849, at Dorchester, Mass., and, after receiving his preliminary training in this country, studied four years at the School of Mines in Freiberg, Saxony. After spending five years in Colorado he studied medicine, but later returned to his metallurgical work, and has since been engaged successively by the Orford Copper Company, the Canadian Copper Company in Ontario, the Calumet & Hecla in Michigan, and the Parrot in Montana. During the year 1893 he was engaged in examining the copper mines of Tasmania, and nearly all the copper mines and works in Europe. Dr. Peters is, therefore, exceptionally well qualified to prepare the exhaustive article on "Improvements in the Metallurgy of Copper," which he has contributed to this volume of THE MINERAL INDUSTRY.

PRESTON, ROBERT E., Director of the United States Mint, has courteously furnished us with much information concerning the distribution, production, coinage, etc., of the precious metals. Mr. Preston entered the government service in 1856 as a clerk in the office of the First Auditor of the Treasury. When the present organization of the Mint Bureau was completed in 1873 he was transferred to that bureau and appointed examiner. Shortly afterward he was placed

in charge of the statistical work and retained that position until September, 1893, when he succeeded Mr. E. O. Leech as Director of the Mint. We are under many obligations to Mr. Preston for his courteous assistance in this work.

RAHT, AUGUST, born in Nassau, Germany, in 1843; after finishing his education as mining engineer, in different schools and by practical work in different mines and smelting works, he came to the United States in 1865. Shortly after this he was employed as superintendent at the copper mines and smelting works at Ducktown, Tenn., remaining there for ten years. After a visit to Germany he was engaged as superintendent of different lead smelting works near Salt Lake City. While engaged here he found by many experiments and careful observation, in conjunction with Mr. Anton Eilers, that it is essential in lead smelting to have a composition of slag in which the ratio between oxide of iron and lime is a simple one; a fact which is now well recognized and acted upon by all successful lead smelters of the United States. After professional visits to New Mexico and Arizona he was engaged again in 1880 as superintendent at the lead smelting works of Messrs. Mather & Geist at Pueblo, and after that at the smelting works of the Horn Silver Mining Company near Salt Lake City, where he treated successfully the ores from the Horn silver mine. In 1884 Mr. Raht managed the smelting works near Helena, Mont., and has now for some years been superintendent and manager of the Philadelphia smelter at Pueblo, Colo. Mr. Raht has contributed a large share to the perfection in lead smelting in the United States, which has established the superiority of American practice over that of any other country, and his skill has given him in the profession the title of "the prince of lead smelters." Mr. Raht took out a patent in 1865 for the bessemerizing of copper matter, but did not then succeed in introducing it on a commercial scale for want of capital. This is the same process since operated successfully under a French patent at the Parrot Copper Works in Butte, Mont. Mr. Raht has written for this volume an article on the "Distribution of Silver in Lead Bullion."

RANDOL, J. B., has long been our highest authority on quicksilver trade statistics. He has contributed much of the statistical matter relating to "Quicksilver" in this volume. For many years Mr. Randol was manager of the New Almaden Quicksilver Mining Company of California. Since his retirement from that position he has been engaged in conducting operations on his own account.

RAYMOND, ROSSITER WORTHINGTON, PH. D., is well known from one end of the world to the other as the highest authority in America on Mining Law, and he contributes to this volume an article on the "Influence of the United States Mining Law on the Development of its Mineral Resources." For many years Dr. Raymond was the editor of the *Engineering and Mining Journal* and was practically its founder. He was for several terms president of the American Institute of Mining Engineers, and has for many years been its most efficient secretary. Educated as a mining engineer at Freiberg, Saxony, in the days before mining schools were established in the United States, he quickly became one of the most prominent engineers in this country, and was influential in framing its early mining laws. No one else could speak with such authority on their influence on the marvelous development of the mineral resources of the country.

RICHARDS, ROBERT HALLOWELL, Professor of Mining and Metallurgy at the Massachusetts Institute of Technology; Past President American Institute of Mining Engineers. Born in 1844, at Gardiner, Me. In 1868 he graduated in the first class from the Institute of Technology and became assistant in chemistry in the Institute, passing successively to the posts of instructor, assistant professor of chemistry, professor of mineralogy and assaying, professor of mining engineering, and in 1884 to his present professorship of mining and metallurgy. Under his administration the school's mining and metallurgical laboratory has been developed to a high state of excellence. Professor Richards has also been actively engaged in professional work, and has been a prominent contributor of valuable papers to the technical press and various scientific societies. He has contributed to this volume an article on "Improvements in Ore Dressing."

RICKARD, THOMAS ARTHUR, E. M. Born in 1864, at San Terenzo, Italy. Educated in Russia and England, graduating at Royal School of Mines, London, in 1885. Since then has

SOME OF THE CONTRIBUTORS TO THE MINERAL INDUSTRY.

GEORGE LUNGE.

F. J. H. MERRILL.

WILLIAM NELSON PAGE.

EDWARD DYER PETERS, JR.

ROSSITER W. RAYMOND.

ROBERT H. RICHARDS.

THOMAS ARTHUR RICKARD.

been engaged professionally managing mines in Colorado and in professional examinations in various Western States, and in Australia and New Zealand. Mr. Rickard is located as a consulting mining engineer in Denver and is State Geologist of Colorado. He is a member of various scientific societies and a well-known contributor to the literature of his profession. He has contributed to this volume a timely article on the gold resources of Colorado.

SMITH, EUGENE ALLEN, born in Washington, Ala., in 1841, graduated from the University of Alabama in 1862 and was for time instructor in that institute. From 1865 to 1868 he spent his time studying in Germany; from 1868 for several years he was assistant in the Geological Survey of Mississippi being largely employed in making analyses of soils. In 1873 he was appointed Assistant State Geologist of Alabama and is now State Geologist, to which is added the professorship of mineralogy and geology in the University of Alabama. He has also served as commissioner to the Paris Exposition of 1878 and as special commissioner of the Tenth United States Census and is prominently connected with the American Geological Society, the American Association for the Advancement of Science, and the Alabama Industrial and Scientific Society. Dr. Smith is the author of elaborate papers on the Geology of the Mississippi Bottom," on "Florida Phosphates," and of a number of reports for the State Geological Survey, besides a very full report on cotton cultivation in Alabama and Florida for the Eleventh Census. He has contributed to this volume of THE MINERAL INDUSTRY a variety of information with regard to the mineral resources of Alabama.

SMOCK, JOHN C., State Geologist of New Jersey, has long been connected with the Geological Survey of New Jersey. Mr. Smock has contributed to this volume notes on "Marls," a subject with which he is thoroughly conversant; also information on other mineral products of New Jersey. The admirable work done by the Geological Survey of New Jersey is well known, and much of its excellence is due to Professor Smock's care, both while he was assistant to the late Professor Cook, and since that gentleman's death, as chief of the survey.

SPRAGUE, TIMOTHY WILSON, graduate Massachusetts Institute of Technology, class of 1887, mining department. After graduation remained as assistant to Prof. Robert H. Richards one year, then for a year was on the staff of the *Electrical Review*, part of the time as assistant editor. He then became connected with the Thomson-Houston Electric Company in its motor and mining department and remained with it and its successor, the General Electric Company, five years. He was one year with the engineering firm of Westinghouse, Church, Kerr & Co., and is now consulting engineer in New York, his specialties being electrical mining installations and power transmission. Mr. Sprague has written for Volume III. the article on "Electrical Transmission of Power in Mining."

STANTON, JOHN, Secretary and Treasurer of the Atlantic, the Allouez, the Central and the Wolverine Copper Mining Companies of Michigan, whose affairs he has conducted with great ability and with marked success. Mr. Stanton has for the past three years acted as statistician for the great copper producers in their monthly exchange of statistics with the European producers, and has contributed to this volume statistical information relating to the copper production of the United States.

THIES, FERDINAND FRANZ, was born in Riga, Russia, in 1851. He studied at the Gymnasium, at the Baltic Polytechnicum in Riga, and at the Royal High School at Aachen in Germany. He passed the State Examination at the Baltic Polytechnic and received the gold medal and a diploma as marine and road engineer for Russia. After taking part in various technical enterprises in the Province of Livonia he was called to Riga in the year 1877 as second city engineer. This position he filled until 1884 when he made a trip to Germany for study, and in 1885 was again chosen as civil engineer of Riga. While in this position he took part in the preliminary work for the sewer system of the city and was the chief engineer in the construction of the wharves in Riga. In 1888 he was chosen chief engineer and technical director of road, and bridge constructions in the Province of Livonia. In 1891 he withdrew from Russia and took up his residence in Germany. Since 1891 he has been the architect in the Technical Bureau in the Department of Foundations (Tiefbau) in Berlin and technical contributor to various journals principally relating to mining and metallurgy in Russia. His contribution to the present volume is the elaborate article on "Russia and the Mineral Resources of Siberia."

ULKE, TITUS, Met. E., born in 1866, at Washington, D. C. In 1889 he graduated from the Royal School of Mines at Freiberg, Saxony, as metallurgical engineer. After spending some time in visiting the various mines and metallurgical works of Europe, Mr. Ulke returned to this country and was engaged as chemist to the Harney Peak Tin Company in South Dakota. In 1891 he became assayer for the United Smelting Company, and afterward was engaged by the Anaconda Mining Company as chemist at its electrolytic copper refining works. In 1893 Mr. Ulke acted as metallurgist to the Mines and Mining Department of the Chicago Columbian Fair, and is now connected with the great refining works of the Guggenheims at Perth Amboy N. J. Mr. Ulke has contributed articles on the "Progress of the Electrolytic Alkali Manufacture," on "Electroplating," and on "Electrolytic Copper Refining" to this volume.

VAN ESVELD, W. C., of Surinam, Dutch Guiana, Chief Director of the Surinaamsche Bank, in that capacity has a wide acquaintance with the business of Dutch and British Guiana. He has courteously furnished the statistics of the gold production of British and Dutch Guiana, which, are given with great completeness.

VON ERNST, CARL, RITTER, Superior Counselor of Mines, Counselor of Regency, Counselor of Commerce, Director of the Commercial Affairs of the Austrian Government Mines. Born Oct. 1, 1833, at Zara, Dalmatia, Austria; studied in the Technical Academy at Prague (Bohemia) and in the Mining Academy at Schemnitz (Hungary), and in 1855 entered the Government service; was engaged in the State's service at Venice, Lombardy, and Vienna, and appointed by the Government to travel over the mining districts of Italy and of the island of Sardinia. In 1874 he became director of the commercial affairs of the Austrian Government's mines. In 1881, in company with Professor Höfer at Leoben (Styria), he engaged in editing the *Oestereichische Zeiteschrift für Berg-und Hüttenwesen*, and some years later the publication of the annals of the Mining Academy at Leoben (Styria), Przibram (Bohemia), and Schemnitz (Hungary). Ritter von Ernst is one of the most eminent statisticians in Europe; he has contributed to this volume statistics and other valuable information of the mining industry of Austria-Hungary and of Bosnia.

VAN VORSTENBERG, BERNARD, born 1856, in Amsterdam, Holland, was educated at various institutions, in Switzerland, Austria, Holland, and at Conway College, Conway, North Wales, and later received the degree of Bachelor of Arts from Christ Church College, Cambridge, England. From 1878 to 1887 he was engaged in the glass manufacturing industry, part of the time as manufacturer, and later representing the Dutch Plate Glass Company of Amsterdam Holland, in all civilized countries of the world. In 1885 he was one of the originators of the first Netherlands Trading Association doing business in the Transvaal, South Africa, acting as secretary until 1887. From 1887 to 1891 he represented a syndicate in the East Indies for the purpose of obtaining concessions in Sumatra on lands, and certain mining rights in the Rhio Archipelago, Borneo and Siam. Has rendered valuable assistance in the collection of the statistics in this volume of THE MINERAL INDUSTY.

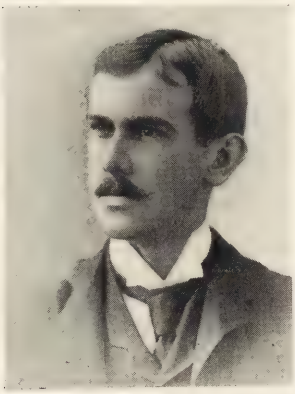
WALKER, EDWARD, London representative of the *Engineering and Mining Journal* and the Scientific Publishing Company. Born in 1865 and educated at Owens College, Manchester, England, where he took the degrees of B. Sc. and M. Sc., in 1886, and 1889, respectively. Mr. Walker has served on the editorial staff of *Industries*, London, and the *Engineering and Mining Journal*, New York, and now practices as a consulting engineer chiefly in connection with law cases and patents, and is the accredited representative in charge of the London offices of the *Engineeriny and Mininy Journal* and the Scientific Publishing Company. Mr. Walker has contributed to this volume much information concerning the mining stocks dealt in in London.

That most important department of this work, its business and financial administration, has been under the control of Mrs. Sophia Braeunlich, treasurer and business manager of the Scientific Publishing Company and of the *Engineering and Mining Journal*, and who was for many years on the staff of that paper. To her remarkable business ability is due in no small degree the success which has crowned this undertaking.

SOME OF THE CONTRIBUTORS TO THE MINERAL INDUSTRY.

W. R. SHIELDS.

EUGENE A. SMITH.



TIMOTHY W. SPRAGUE.

F. THEISS.

TITUS ULKE.

CARL RITTER VON ERNST.

SOPHIA BRAEUNLICH.

been engaged professionally managing mines in Colorado and in professional examinations in various Western States, and in Australia and New Zealand. Mr. Rickard is located as a consulting mining engineer in Denver and is State Geologist of Colorado. He is a member of various scientific societies and a well-known contributor to the literature of his profession. He has contributed to this volume a timely article on the gold resources of Colorado.

SMITH, EUGENE ALLEN, born in Washington, Ala., in 1841, graduated from the University of Alabama in 1862 and was for time instructor in that institute. From 1865 to 1868 he spent his time studying in Germany; from 1868 for several years he was assistant in the Geological Survey of Mississippi being largely employed in making analyses of soils. In 1873 he was appointed Assistant State Geologist of Alabama and is now State Geologist, to which is added the professorship of mineralogy and geology in the University of Alabama. He has also served as commissioner to the Paris Exposition of 1878 and as special commissioner of the Tenth United States Census and is prominently connected with the American Geological Society, the American Association for the Advancement of Science, and the Alabama Industrial and Scientific Society. Dr. Smith is the author of elaborate papers on the Geology of the Mississippi Bottom," on "Florida Phosphates," and of a number of reports for the State Geological Survey, besides a very full report on cotton cultivation in Alabama and Florida for the Eleventh Census. He has contributed to this volume of THE MINERAL INDUSTRY a variety of information with regard to the mineral resources of Alabama.

SMOCK, JOHN C., State Geologist of New Jersey, has long been connected with the Geological Survey of New Jersey. Mr. Smock has contributed to this volume notes on "Marls," a subject with which he is thoroughly conversant; also information on other mineral products of New Jersey. The admirable work done by the Geological Survey of New Jersey is well known, and much of its excellence is due to Professor Smock's care, both while he was assistant to the late Professor Cook, and since that gentleman's death, as chief of the survey.

SPRAGUE, TIMOTHY WILSON, graduate Massachusetts Institute of Technology, class of 1887, mining department. After graduation remained as assistant to Prof. Robert H. Richards one year, then for a year was on the staff of the *Electrical Review*, part of the time as assistant editor. He then became connected with the Thomson-Houston Electric Company in its motor and mining department and remained with it and its successor, the General Electric Company, five years. He was one year with the engineering firm of Westinghouse, Church, Kerr & Co., and is now consulting engineer in New York, his specialties being electrical mining installations and power transmission. Mr. Sprague has written for Volume III. the article on "Electrical Transmission of Power in Mining."

STANTON, JOHN, Secretary and Treasurer of the Atlantic, the Allouez, the Central and the Wolverine Copper Mining Companies of Michigan, whose affairs he has conducted with great ability and with marked success. Mr. Stanton has for the past three years acted as statistician for the great copper producers in their monthly exchange of statistics with the European producers, and has contributed to this volume statistical information relating to the copper production of the United States.

THIES, FERDINAND FRANZ, was born in Riga, Russia, in 1851. He studied at the Gymnasium, at the Baltic Polytechnicum in Riga, and at the Royal High School at Aachen in Germany. He passed the State Examination at the Baltic Polytechnic and received the gold medal and a diploma as marine and road engineer for Russia. After taking part in various technical enterprises in the Province of Livonia he was called to Riga in the year 1877 as second city engineer. This position he filled until 1884 when he made a trip to Germany for study, and in 1885 was again chosen as civil engineer of Riga. While in this position he took part in the preliminary work for the sewer system of the city and was the chief engineer in the construction of the wharves in Riga. In 1888 he was chosen chief engineer and technical director of road, and bridge constructions in the Province of Livonia. In 1891 he withdrew from Russia and took up his residence in Germany. Since 1891 he has been the architect in the Technical Bureau in the Department of Foundations (Tiefbau) in Berlin and technical contributor to various journals principally relating to mining and metallurgy in Russia. His contribution to the present volume is the elaborate article on "Russia and the Mineral Resources of Siberia."

ULKE, TITUS, Met. E., born in 1866, at Washington, D. C. In 1889 he graduated from the Royal School of Mines at Freiberg, Saxony, as metallurgical engineer. After spending some time in visiting the various mines and metallurgical works of Europe, Mr. Ulke returned to this country and was engaged as chemist to the Harney Peak Tin Company in South Dakota. In 1891 he became assayer for the United Smelting Company, and afterward was engaged by the Anaconda Mining Company as chemist at its electrolytic copper refining works. In 1893 Mr. Ulke acted as metallurgist to the Mines and Mining Department of the Chicago Columbian Fair, and is now connected with the great refining works of the Guggenheims at Perth Amboy N. J. Mr. Ulke has contributed articles on the "Progress of the Electrolytic Alkali Manufacture," on "Electroplating," and on "Electrolytic Copper Refining" to this volume.

VAN ESVELD, W. C., of Surinam, Dutch Guiana, Chief Director of the Surinaamsche Bank, in that capacity has a wide acquaintance with the business of Dutch and British Guiana. He has courteously furnished the statistics of the gold production of British and Dutch Guiana, which, are given with great completeness.

VON ERNST, CARL, RITTER, Superior Counselor of Mines, Counselor of Regency, Counselor of Commerce, Director of the Commercial Affairs of the Austrian Government Mines. Born Oct. 1, 1833, at Zara, Dalmatia, Austria; studied in the Technical Academy at Prague (Bohemia) and in the Mining Academy at Schemnitz (Hungary), and in 1855 entered the Government service; was engaged in the State's service at Venice, Lombardy, and Vienna, and appointed by the Government to travel over the mining districts of Italy and of the island of Sardinia. In 1874 he became director of the commercial affairs of the Austrian Government's mines. In 1881, in company with Professor Höfer at Leoben (Styria), he engaged in editing the *Oestereichische Zeiteschrift für Berg-und Hüttenwesen*, and some years later the publication of the annals of the Mining Academy at Leoben (Styria), Przibram (Bohemia), and Schemnitz (Hungary). Ritter von Ernst is one of the most eminent statisticians in Europe; he has contributed to this volume statistics and other valuable information of the mining industry of Austria-Hungary and of Bosnia.

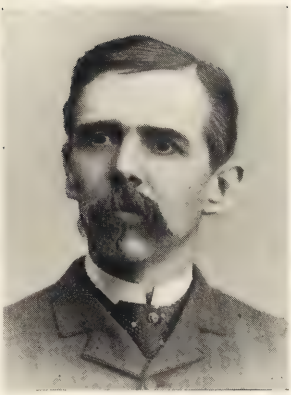
VAN VORSTENBERG, BERNARD, born 1856, in Amsterdam, Holland, was educated at various institutions, in Switzerland, Austria, Holland, and at Conway College, Conway, North Wales, and later received the degree of Bachelor of Arts from Christ Church College, Cambridge, England. From 1878 to 1887 he was engaged in the glass manufacturing industry, part of the time as manufacturer, and later representing the Dutch Plate Glass Company of Amsterdam Holland, in all civilized countries of the world. In 1885 he was one of the originators of the first Netherlands Trading Association doing business in the Transvaal, South Africa, acting as secretary until 1887. From 1887 to 1891 he represented a syndicate in the East Indies for the purpose of obtaining concessions in Sumatra on lands, and certain mining rights in the Rhio Archipelago, Borneo and Siam. Has rendered valuable assistance in the collection of the statistics in this volume of THE MINERAL INDUSTY.

WALKER, EDWARD, London representative of the *Engineering and Mining Journal* and the Scientific Publishing Company. Born in 1865 and educated at Owens College, Manchester, England, where he took the degrees of B. Sc. and M. Sc., in 1886, and 1889, respectively. Mr. Walker has served on the editorial staff of *Industries*, London, and the *Engineering and Mining Journal*, New York, and now practices as a consulting engineer chiefly in connection with law cases and patents, and is the accredited representative in charge of the London offices of the *Engineeriny and Mininy Journal* and the Scientific Publishing Company. Mr. Walker has contributed to this volume much information concerning the mining stocks dealt in in London.

That most important department of this work, its business and financial administration, has been under the control of Mrs. Sophia Braeunlich, treasurer and business manager of the Scientific Publishing Company and of the *Engineering and Mining Journal*, and who was for many years on the staff of that paper. To her remarkable business ability is due in no small degree the success which has crowned this undertaking.

SOME OF THE CONTRIBUTORS TO THE MINERAL INDUSTRY.

W. R. SHIELDS.



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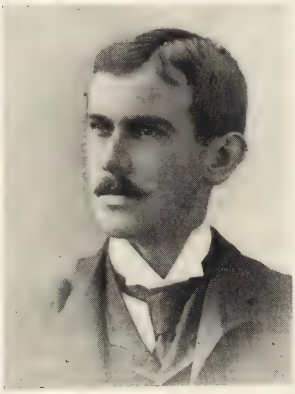

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INTRODUCTION.

Mineral and Metal Production of the United States in 1893 and 1894.

The accompanying table gives the output of all the chief articles of mineral production in the United States for the years 1893 and 1894 and their approximate value.

While no statistics of this kind, collected from a country as large as our own, and with as varied industries, can be absolutely correct, it is believed that these figures are the most accurate and the fullest that have ever been presented of the mineral industry of the United States. Returns have been received from all the producers in each department and have been carefully checked and compared with all available sources of information. The statistics of production of several articles as published a year ago in Volume II. of this work have been revised by later and more complete data. It is the intention to render these statistics accurate and trustworthy; consequently, when any errors or omissions are discovered, they are corrected in subsequent volumes, so that this work can always be relied upon as containing the most accurate statistics of the mineral industry of the world. Many foreign countries and our United States Director of the Mint revise their statistics for some years after they first appear; it is therefore important to take the figures as given in the latest volume of The Mineral Industry, which are the most authoritative.

The total value of the mineral products of the country, as shown here, was $615,847,108 in 1893, and $553,356,499 in 1894; showing a decrease in values (not quantities) last year of $62,490,609, or 10%. To arrive at the net value of the mineral and metal production in each year, a deduction must be made from the total for that of substances, the value of which has necessarily been duplicated in the tables. Such, for instance, are the antimony ore used in making the metal; the bauxite used in making alum and aluminum; the coal—chiefly slack—used in making coke; the copper used in making sulphate; most of the lead used in making white lead; the manganese ore used in making spiegeleisen and ferromanganese, which are included in pig iron; zinc used in making zinc oxide, etc. A careful estimate of the proper amount of these deductions gives $15,000,000 in 1893 and $13,000,000 in 1894, which would leave the net total value of our mineral production in 1893 equivalent to $600,847,108; and in 1894 equivalent to $540,356,499.

To make a fair comparison between the two years, the quantities of the several articles produced should be examined. It is impossible to give any total in quantities when so many materials and different units of measure are used. The only total that can be given is that of values, and the decrease in this amount is in most cases very much greater than the falling off in quantities produced. The year 1894 will long be remembered as one of low prices and in almost every industry values were brought down to a point lower than had ever been before known. For instance, the production of bituminous coal, which is really an index to the condition of the manufacturing industry, showed a decrease from 1893, notwithstanding the strikes which prevailed, of only 11,000,000 tons, or about 9%, while that of anthracite coal actually increased by 4,700,000 tons, or nearly 10%; so that the decrease in the total output of fuel was less than 6,221,000 tons, or 3½%, while the decline in value was 7%. In pig iron the decrease was only about 400,000 tons, and this loss was in the earlier part of the year, while at the close of 1894 the furnaces were running at a rate which promises to make the production of 1895 exceed 9,000,000 tons, which has thus far been the highest mark of our production. In copper there was an actual increase of 26,250,000 lbs., the decline in home consumption being offset by a large increase in exports; but the value decreased by $1,639,508. Again, the production of zinc decreased only 2250 tons, or about 3%, while the value reported was less by about $1,000,000, or 16.6%. The decrease in the production of pig iron was 386,000 tons, or 5.5%, while the decrease in value was $21,900,000, or nearly 24%. Many other and similar instances might be taken from the table to show that the total reduction in value of the mineral production of $62,490,608, or 10%, represented very much less than that proportion—probably not over 5 or 6%—in actual quantities produced.

The silver production of the United States was maintained at a much higher level than had been expected. In 1893 the production was 60,500,000 ozs., worth $47,311,000, a decrease of 4,500,000 ozs. from 1892, when it reached its highest level. The decrease in 1894 was only 10,653,125 ozs., or about 18%, but in value the decline amounted to $15,907,469, or 33.6%. The reduction still leaves the United States the greatest silver producer in the world, and the industry is, and doubtless will continue to be, a very important one.

The "commercial" value for silver has been used instead of its United States coining value, as is done by the United States Mint. Since all silver produced in the United States is sold at its commercial value it would be manifestly improper, in a table giving the values of the mineral and metal products of the United States, to either count the value of silver, or copper, or nickel, at the artificial rate the government is able to give them in coin, so long as it is able to maintain their exchangeability for gold at the assumed values.

Perhaps the most notable feature of the year is the increase in the output of gold, which last year was $39,764,708, an increase of $3,809,708 over 1893, and of $6,749,727 over 1892. The full effect of the revival of gold mining is not yet apparent, and 1895 will undoubtedly show a further gain. This increase in gold output was not confined to any one of the producing States, but was distributed over nearly all of them, and came from both placers and vein mining.

A point worthy of special note in relation to the output of gold is that the

actual cost of mining and treating gold ores is now probably lower than ever before. Almost anywhere through our Western mining districts, with wages from $2.50 to $3.50 per day, the cost of crushing, roasting and chlorinating ores in a plant working 100 tons a day can be made less than $3 per ton. In cases where the ore yields more than $10 a ton in gold it is usually more economical to roast and chlorinate without concentrating than to concentrate the ore and then treat the concentrates, because the loss in the concentration process will, in most cases, exceed the cost of roasting and concentrating. It is also true that in a well arranged furnace the cost of roasting 100 tons of unconcentrated ore would be very little greater than the cost of treating, say 15 tons of concentrates derived from the 100 tons of raw ore. The cost of extracting gold by the cyanide processes from ores adapted to them is something less than the cost of chlorination.

The time is evidently ripe for applying improved processes to the treatment of low grade gold ores, of which we have great quantities at many different points in the Rocky Mountain Region and on the Pacific coast, as well as in the Southern States.

Some changes have been made in classification in this table. Abrasives are collected under one heading. Asbestos and talc, some varieties of which are difficult to separate, are here brought together. Stone includes all of many varieties used in building; it must, however, be stated that the estimates of value of the building stone production are unsatisfactory, for it is impossible to get returns from all the quarries, many of which are worked intermittently on a very small scale for the supply of a local market, and no records are kept by those who work them. The same is true of the estimate of the value of the lime produced, for no statistics are kept, or can be obtained, of an important part of that product.

The production of so-called "mineral waters" is omitted, as heretofore, from these statistics. Waters cannot properly be considered as minerals except in cases where they are used to extract minerals from, as metals are won from their ores, and as salt, bromine, etc., are extracted from certain waters. All waters contain more or less of mineral matter. If the production of "mineral waters" is to include only the water sold, then the supplies of our town and city water works should be included, and these amount to about 1,000,000,000,000 gallons, or say 41,600,000,000 short tons a year, sold at an aggregate value of about $200,000,000. Moreover, the vast amount sold for irrigating or other purposes, and not included in the above, should not be neglected, while an infinitesimal 95,000 tons, largely artificial mixtures, varying from carbon dioxide water to "ginger ale," is cited as to the production of "mineral waters."

The statistics of a number of important substances are given in these tables for the first time. Thus the output of alum, the manufacture of which constitutes a large and profitable industry, is found to have amounted in 1894 to 72,000 short tons, of the value, at the place of production, of $2,160,000. Notwithstanding the importance of this product scarcely any detailed information concerning its manufacture is to be found in technical literature. In accordance with the design of THE MINERAL INDUSTRY, which aims to give full practical information concerning the technology of all the mineral products, this volume

contains the most elaborate and valuable monograph on the manufacture of alum that has yet been written in any language. No doubt the information here given will tend to the extension of this industry.

In all cases the object aimed at has been to present a record of progress in mining and metallurgy, technical as well as statistical, and to add to the figures representing production all possible information as to new processes and improvements; thus making it a periodical photograph of the industry which it represents.

Under the appropriate headings, as arranged alphabetically in this work, will be found the detailed statistics, technical and trade information, concerning the different minerals and metals. The attention devoted to each is in proportion to the progress that has been made in the methods used in its production, and to the needs of detailed information concerning each substance and its uses.

Where detailed descriptions of occurrence and production are readily obtainable, as for example in the case of coal, clay, iron ores, etc., which are treated at great length in the reports of the coal-mine inspectors or State geologists of the several producing States, it has been deemed a waste of space to devote any large part of this volume to compilations of this abundant material.

The subject of gold amalgamation, by which a very large part of the world's gold supply is obtained, and concerning the practical details of which the text-books afford but little, and frequently misleading, light, has received much attention in this volume, as has also a study of the conditions affecting the production of gold and silver and the relative values and costs of these metals.

The marvelous progress in copper metallurgy is treated in the most authoritative manner and brings the technology of this industry literally up to date.

Besides those subjects just specially referred to, the progress in lead metallurgy; in ore dressing; in electricity as applied in mining; in nickel metallurgy; in the manufacture and uses of the metallic oxides, and in other important subjects which are not to be found elsewhere, are here treated in a manner which will be of the utmost practical value in promoting the development and prosperity of the industry.

The full statistics of the mineral production, imports and exports of the United States and other countries given in detail under the appropriate headings in the pages of this volume, are summarized at the end of the book under the names of the various countries.

The years 1893 and 1894 have been critical ones to the mineral industry of the United States, owing to the great depreciation in market prices and the fall especially in the value of silver. The financial panic, the result of which we felt through the two years, and which had its origin in many complicated causes, was immediately due in great measure to this depreciation in silver, resulting from the so-called demonetization of the metal in several commercial countries and the closing of the Indian mints.

It becomes of great interest to study as closely as possible the effects of the various disturbing causes, and to accumulate the material necessary for this we applied to the producers, who, with but few exceptions, have very kindly furnished us with returns of their monthly production for the two years, and from these returns we have compiled the following tables, showing the

MINERAL PRODUCTION OF THE UNITED STATES, 1893 AND 1894.

No.	Products.	Customary Measures.	1893. Quantity. Customary Measures.	1893. Quantity. Metric Tons.	1893. Value at Place of Production.	1894. Quantity. Customary Measures.	1894. Quantity. Metric Tons.	1894. Value at Place of Production.
	NON-METALLIC.							
	Abrasives—							
1	Corundum and emery	Short tons	1,747	1,585	$140,589	1,220	1,106	$109,500
2	Garnet	"	1,520	1,379	55,800	1,000	907	35,000
3	Grindstones	"	45,340	41,133	345,920	37,400	33,922	335,800
4	Millstones	"	155	141	2,359	297	269	4,447
5	Tripoli and infus. earth	"	1,351	1,226	25,625	1,802	1,634	36,687
6	Whetstones	"	1,903	1,726	89,550	1,735	1,574	84,450
7	Alum	"	96,000	87,093	2,880,000	72,000	65,304	2,160,000
8	Antimony ore	"	850	771	41,000	165	150	9,075
	Asbestos and Talc—							
9	Asbestos	"	120	109	6,000	250	227	3,750
10	Fibrous talc	"	36,500	33,113	337,625	39,600	35,917	396,000
11	Talc and soapstone	"	20,100	18,235	366,825	21,044	19,087	401,892
12	Asphalt	"	3,490	3,166	68,682	4,198	4,080	75,654
13	Bituminous rock	"	31,404	28,489	114,752	34,199	31,018	148,120
14	Barytes	Long tons	26,632	27,067	133,160	23,758	24,141	95,032
15	Bauxite	"	11,041	11,222	55,205	10,732	10,908	42,928
16	Borax	Pounds	9,199,000	4,173	689,925	13,140,589	5,962	919,841
17	Bromine	"	348,399	158	87,100	379,444	172	98,655
18	Cement, natural hydraulic	Bbls., 300 lbs.	7,445,950	1,013,238	5,010,958	7,895,259	1,074,179	4,397,407
19	Cement, Portland	"	673,989	91,715	1,052,173	738,196	100,352	1,080,644
20	Clay, refractory	Short tons	3,214,989	2,916,591	4,822,483	3,375,788	3,061,794	4,050,885
21	Clay, kaolin	"	30,183	27,382	205,667	24,552	22,246	185,169
22	Coal, anthracite	"	a47,355,387	42,960,116	74,605,885	a52,010,433	47,183,345	80,879,404
23	Coal, bituminous	"	a128,826,364	116,869,397	123,899,415	a117,950,348	106,953,311	103,842,467
24	Coke	"	8,939,961	8,110,245	14,706,544	8,495,295	7,706,846	12,654,558
25	Cobalt oxide	Pounds	3,894	2	5,452	6,550	3	8,843
26	Copperas	Short tons	17,862	16,204	134,520	14,897	13,511	104.160
27	Copper sulphate	Pounds	54,000,000	24,492	1,822,500	e60,000,000	27,215	2,016,000
28	Chrome ore	Long tons	1,629	1,646	16,000	2,653	2,697	35,125
29	Feldspar	"	17,000	17,274	85,000	23,280	23,655	116,400
30	Fluorspar	Short tons	9,700	8,800	63,070	9,000	8,165	64,000
31	Graphite	Pounds	882,912	400	39,731	770,846	349	34,689
32	Graphite, amorphous	Short tons	1,691	1,534	8,996	165	150	1,252
33	Gypsum	"	330,231	299,582	927,615	287,517	260,834	849,925
34	Lime	Bbls., 200 lbs.	e60,000,000	5,443,164	30,000,000	e56,750,000	5,148,326	28,375,000
35	Magnesite	Short tons	1,143	1,037	8,000	1,370	1,243	4,864
36	Manganese ore	Long tons	9,150	9,297	60,000	11,735	11,924	74,899
37	Mica, ground	Pounds	679,000	308	29,522	829,500	377	35,957
38	Mica, sheet	"	6,500	3	5,478	9,900	4	11,103
39	Monazite	"	130,000	59	7,600	750,000	340	45,000
40	Natural gas	.....	.....	.....	14,000,000	.....	.....	11,000,000
41	Paints, mineral	Short tons	44,709	40,559	726,160	38,801	35,200	662,262
42	Paints, vermilion	"	37	34	40,000	41	37	45,600
43	Paints, white lead	"	88,500	80,286	9,469,500	87,242	78,155	8,445,174
44	Paints, zinc oxide	"	25,000	22,679	1,875,000	22,814	20,697	1,711,275
45	Petroleum (crude)	Bbls., 42 gals.	50,349,228	7,043,857	32,223,505	48,527,336	6,788,974	40,762,962
46	Phosphate rock	Long tons	981,340	997,140	3,434,690	952,155	967,485	2,856,455
47	Marls	"	200,000	203,814	540,000	225,000	228,622	607,500
48	Precious stones	.....	.....	.....	200,000	.....	.....	250,000
49	Pyrites	Long tons	95,000	96,529	285,000	107,462	109,102	466,466
50	Salt, evaporated	Bbls., 280 lbs.	9,703,419	1,232,392	4,945,583	9,161,053	1,163,508	4,608,275
51	Salt, rock	"	1,935,642	245,838	678,064	2,341,922	297,438	788,681
52	Silica, sand and quartz	Long tons	300,000	304,814	330,824	315,531	320,610	347,951
53	Slate, roofing	Squares	803,887	237,014	2,956,895	693,944	204,656	2,551,259
54	Slate, other manufactures	Square feet	4,138,920	.....	475,681	5,099,791	.....	499,578
55	Soda, natural	Short tons	2,500	2,268	12,500	.....	.....	.....
56	Soda, natural sulphate	"	90	82	450	.....	.....	.....
57	Stone, limestone (flux)	Long tons	3,750,000	3,810,375	2,250,000	3,544,396	3,601,458	2,126,636
58	Stone, marble	Cubic feet	5,639,681	429,399	2,087,758	5,681,766	433,093	2,177,280
59	Stone, onyx	"	2,175	166	28,750	1,450	110	29,000
60	Other building stones	.....	.....	.....	e38,000,000	.....	.....	e30,000,000
	Total non-metals	.....	.....	.....	377,517,086	.....	.....	353,760,877
	METALS.							
61	Aluminum	Pounds	312,000	142	202,800	817,600	371	490,560
62	Antimony	Short tons	350	318	63,000	220	205	39,200
63	Copper	Pounds	327,255,788	148,441	35,179,997	353,504,314	160,392	33,540,489
64	Gold	Troy ounces	1,739,323	*54,093	35,955,000	1,923,619	*59,824	39,764,708
65	Iron, pig	Long tons	7,043,384	7,156,782	93,888,309	6,657,388	6,764,572	71,966,364
66	Lead, value at New York	Short tons	166,678	152,080	12,434,178	160,867	145,906	10,585,048
67	Nickel, fine	Pounds	25,893	*11,745	12,429	.....	.....	.....
68	Quicksilver	Flasks, 76½ lbs	30,164	1,046	1,108,527	30,440	1,056	1,095,840
69	Silver, commercial value	Troy ounces	60,500,000	*1,881,731	47,311,000	49,846,875	*1,550,387	31,403,531
70	Zinc spelter	Short tons	76,255	69,178	6,214,782	74,004	67,135	5,209,882
	Total metals	.....	.....	.....	232,370,022	.....	.....	194,095,622
	Est. products unspecified	.....	.....	.....	6,000,000	.....	.....	5,500,000
	Grand total	.....	.....	.....	615,847,108	.....	.....	553,356,499

(a) Bituminous coal includes brown coal and lignite. The anthracite production is the total for Pennsylvania, Arkansas and Colorado. (e) Estimated. * Kilograms.

monthly output in the United States of gold, silver, copper, lead, zinc and pig iron, and the average monthly prices of the metals. We have also shown the curve of the monthly production graphically in the very interesting diagram which is given on the opposite page. The production of gold, silver and lead in this table includes the metal smelted or refined from foreign as well as domestic material. The amount of each is given under the special subject elsewhere in this book.

MONTHLY PRODUCTION AND PRICES OF THE CHIEF METALS IN 1893 AND 1894.

1893.

Metals.	January.	February.	March.	April.	May.	June.
Gold, ounces	136,829	118,975	127,386	131,610	145,559	129,046
Silver, ounces	7,593,906	6,828,041	6,823,455	6,607,696	7,693,736	8,066,752
Price per oz.	84.12c.	84.38c.	83.71c.	83.74c.	84.08c.	81.30c.
Copper, short tons	11,397	10,365	11,632	15,013	15,347	14,073
Price per lb.	12.13c.	12.00c.	11.88c.	11.38c.	11.00c.	11.00c.
Lead, short tons	19,910	18,437	18,620	18,335	18,736	20,599
Price per lb.	3.89c.	4.22c.	3.96c.	4.08c.	3.89c.	3.77c.
Spelter, short tons	7,054	6,453	7,052	6,783	6,794	6,326
Price per lb.	4.39c.	4.33c.	4.28c.	4.38c.	4.41c.	4.27c.
Pig iron, long tons	771,027	724,477	750,953	771,189	791,271	782,810
Price per ton, gray forge	$12.30	$12.25	$12.25	$12.25	$12.20	$12.15
Price per ton, Bessemer pig	13.50	13.50	13.75	13.85	13.50	13.50

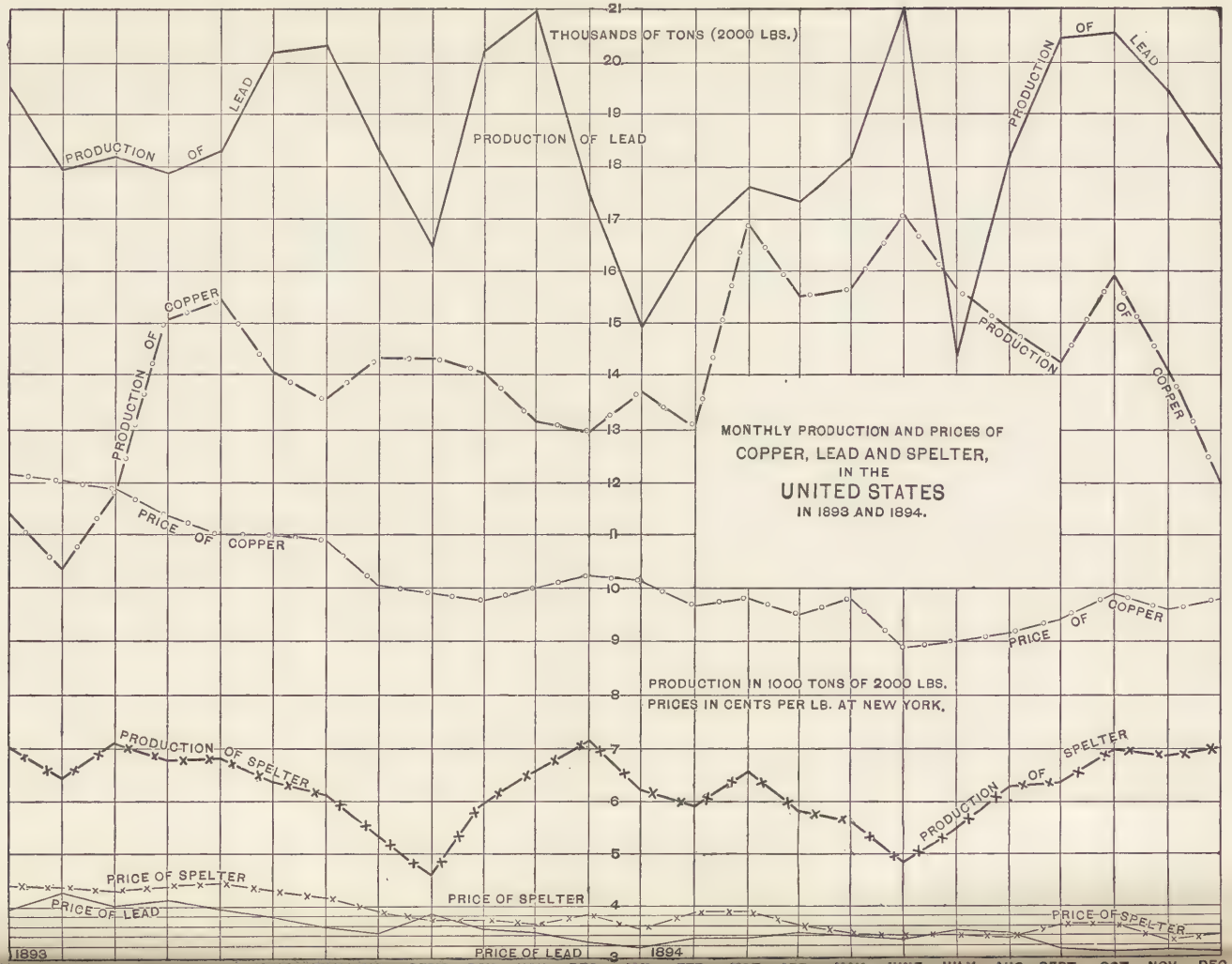
Metals.	July.	August.	September.	October.	November.	December.	Year.
Gold, ounces	146,420	183,221	189,631	186,783	183,436	164,699	1,843,595
Silver, ounces	8,273,470	7,047,899	6,203,649	5,727,728	5,724,696	6,746,788	83,337,816
Price per oz.	72.33c.	74.85c.	75.21c.	73.71c.	70.95c.	70.25c.	78.22c.
Copper, short tons	13,540	14,305	14,327	14,050	13,156	12,969	143,969
Price per lb.	10.88c.	10.00c.	9.88c.	9.75c.	10.00c.	10.25c.	10.75c.
Lead, short tons	20,725	18,674	16,924	20,604	20,407	17,857	230,844
Price per lb.	3.58c.	3.41c.	3.80c.	3.51c.	3.41c.	3.27c.	3.73c.
Spelter, short tons	6,144	5,349	4,564	5,968	6,584	7,184	76,255
Price per lb.	4.13c.	3.89c.	3.69c.	3.68c.	3.65c.	3.80c.	4.075c.
Pig iron, long tons	624,178	487,079	371,352	315,838	341,605	361,605	7,043,384
Price, ton, gray forge	$12.10	$11.75	$11.50	$10.80	$10.50	$10.30	$11.77
Price, ton, Bes'mer pig	13.30	12.90	12.25	11.65	11.30	11.00	12.87

1894.

Metals.	January.	February.	March.	April.	May.	June.
Gold, ounces	155,692	135,812	136,794	142,226	142,084	151,178
Silver, ounces	6,082,769	5,562,062	6,828,356	5,541,996	5,097,612	5,530,699
Price per oz.	67.91c.	63.43c.	59.40c.	62.92c.	62.76c.	62.57c.
Copper, short tons	13,632	13,074	16,910	15,472	15,688	17,148
Price per lb.	10.13c.	9.63c.	9.81c.	9.50c.	9.80c.	8.94c.
Lead, short tons	15,176	17,019	18,031	17,717	18,452	20,311
Price per lb.	3.19c.	3.31c.	3.37c.	3.43c.	3.39c.	3.31c.
Spelter, short tons	6,227	5,852	6,554	5,863	5,657	4,873
Price per lb.	3.56c.	3.85c.	3.89c.	3.62c.	3.47c.	3.40c.
Pig iron, long tons	458,797	417,517	526,210	582,857	483,966	315,076
Price per ton, gray forge	$9.91	$9.77	$9.62	$9.51	$9.71	$9.86
Price per ton, Bessemer pig	10.80	10.69	10.31	10.34	12.02	15.59

Metals.	July.	August.	September.	October.	November.	December.	Year.
Gold, ounces	165,728	219,151	207 329	210,103	189,414	185,873	2,041,384
Silver, ounces	4,347,800	6,481,126	5,817,017	6,285,043	6,239,766	6,375,322	70,189,568
Price per oz.	62.45c.	63.88c.	64.14c.	63.06c.	63.13c.	60.48c.	63.00c.
Copper, short tons	15,655	14,912	14,291	15,895	14,161	12,035	159,686
Price per lb.	9.00c.	9.13c.	9.40c.	9.88c.	9.60c.	9.80c.	9.49c.
Lead, short tons	14,781	18,581	20,843	20,924	19,754	18,363	220,955
Price per lb.	3.50c.	3.41c.	3.17c.	3.12c.	3.14c.	3.10c.	3.29c.
Spelter, short tons	5,458	6,266	6,309	6,986	6,912	7,047	74,004
Price per lb.	3.43c.	3.38c.	3.44c.	3.45c.	3.36c.	3.43c.	3.52c.
Pig iron, long tons	400,426	528,466	683,901	706,618	750,178	803,376	6,657,388
Price, ton, gray forge	$10.00	$10.03	$10.16	$9.94	$9.73	$9.47	$9.80
Price, ton, Bes'mer pig	12.26	15.01	11.32	11.02	13.36	10.24	11.91

During the early part of the summer of 1893 the operations of the Sherman act, under which the United States Treasury purchased 4,500,000 ozs. of silver


THOUSANDS OF TONS (2000 LBS.)
PRODUCTION OF LEAD
PRODUCTION OF COPPER
PRICE OF COPPER
PRODUCTION OF SPELTER
PRICE OF SPELTER
PRICE OF LEAD
MONTHLY PRODUCTION AND PRICES OF
COPPER, LEAD AND SPELTER,
IN THE
UNITED STATES
IN 1893 AND 1894.
PRODUCTION IN 1000 TONS OF 2000 LBS.
PRICES IN CENTS PER LB. AT NEW YORK.
1893
1894

each month, were disturbing financial circles and its repeal was being discussed and very strongly urged. To anticipate the effects of such a repeal on the value of silver, the British authorities in June, 1893, with little or no notice, closed the mints of British India to the coinage of silver. This action caused a sudden and sharp decline in the price of the white metal from about 81c. to 63c. per oz. The Sherman law was not actually repealed until October, 1893.

These causes demoralized the silver market and by direct consequence the lead market also. Many silver-lead mines were closed and the production decreased; apparently this should have raised prices by lessening the output of lead, but such a result did not follow to any extent, as the diagram shows. The probable explanation of this is that the amount of lead exported from Mexico in ore and bullion and smelted and refined here—which is included in our tables and diagram—increased considerably and compensated for loss in the home output.

The production of other metals was reduced by the financial disturbances following the crisis in June, 1893, which at once reduced the demand and caused the stoppage, through uncertainty and lack of confidence in the future, of many manufacturing establishments which were customers for the metals in their raw state. The production of copper alone was sustained, notwithstanding the fall in prices, by the demand from England and the continuous heavy exports.

Business of every kind was further affected by the long continuance of the discussion over the tariff question in Congress and the uncertainty over the final result, and the effect of this is very perceptible in the diagram of production, with the exception, as above noted, of copper. It was not until August 7th, when the new tariff law was finally passed and the question settled for the time, that business fairly began to revive, but even then the revival was retarded by the silver discussion and the uncertainty whether our government would be able to maintain gold payments. It was not until the vigorous and decided action of the government in making the Syndicate contract and loan reassured the people and convinced them of the determination of the government to maintain the financial standing of the United States that confidence was fully established.

To sum up the results shown by our condensed tables, the comparison between the production of 1893 and 1894 shows a moderate decrease in production with a much larger proportional decrease in the values or prices, but in both cases a decrease, the amount of which is less than the general expectation. It shows also that in a year of extremely unfavorable conditions the mineral production of the United States by its extent and variety still gives the country the foremost place among the nations of the world—a place which is, above all, surprising, when we consider the comparatively brief period in which the industry has been built up.

The conditions under which the year closed were far more favorable than those with which it opened. The year 1895 is already beginning to show a great improvement over its predecessor, and there is good reason for hoping that 1896 in its turn will show a development exceeding any which has yet been seen in the history of the mineral industry of the United States.

ABRASIVES.

Carborundum.

By E. G. Acheson.

The year 1894, the third from the date of the discovery of carborundum, and the second of the practical commercial manufacture of the substance, witnessed marked improvement in this industry. Increased skill in manipulating the electric furnaces, together with better adjustment of current, resulted in the production of 52,194 lbs. against 15,200 lbs. in 1893. As was expected, larger crystals or grains were produced, as the result of the increased output; the manufacturers placing on the market grains of No. 20 mesh and finer. While a comparatively small quantity of carborundum in the loose grain form was sold, and the sales of powder showed but a small increase over the preceding year, the business in wheels, hones, and other manufactured forms, grew in a most satisfactory manner. The total sales for the year were valued at $55,000, and of this not less than $30,000 was exported to Europe. There can be no doubt that the domestic consumption would have been much larger had the year been one of normal business activity.

Large reductions were made in the selling price of the grain and manufactured forms of carborundum, amounting in some cases to 75%; the grain being quoted at 50c. per lb. at the close of the year.

Tests of carborundum wheels made in manufacturing establishments in various parts of the United States during the year have given favorable results. Having satisfactory evidence of a future large consumption of the material, the Carborundum Company entered into contracts with the Niagara Falls Power Company for 10,000 electrical horse-power, to be delivered in blocks of 1000 horse-power as required. The company secured four acres of land in close proximity to the power-house of the Niagara Falls Power Company, in the city of Niagara, and at once commenced the erection of a large and substantial plant. The buildings are of masonry, iron and slate, with a present capacity of 3000 horse-power. The plant, it is expected, will be started about April 1, 1895. The intention is to run continuously night and day, using 1000 horse-power at first, and to produce not less than 3000 lbs. of carborundum per day. During 1894 also, the capital stock of the Carborundum Company was increased to $200,000, to provide for the purchase of the property it occupied in Monongahela City, Penn.

Europe became interested in carborundum as a result of the exhibit made by the Carborundum Company at the Columbian Exposition. This interest took form in the purchase by the Landesbank, of Vienna, Austria, of all of the European carborundum patents, with the exceptions of Germany, England and Scandinavia. Early in the year a small plant of 50 horse-power was erected in Bohemia, near the city of Prague, where preliminary work was done in manufacturing. Later in the year this plant was enlarged to about 350 horse-power. It is understood that the Landesbank is preparing to erect a large plant in France. A company was formed in Germany at Iserlohn, with a capital of 600,000 marks, for the purchase of the German patent and erection of works. Preparatory to building a permanent plant an arrangement was made with the city of Barmen to furnish about 150 horse-power of electric current from the municipal lighting station, with which experimental work could be done.

Corundum and Emery.

The principal producing localities in North Carolina, which furnish the largest part of our corundum output, are those of Corundum Hill and Sapphire. Mr. T. Ulke, who visited the principal Southern mines and mills in 1894, reports as follows concerning the occurrence and concentration of corundum ore and the recent emery discovery at Skeena Creek:

Carolina corundum is found in pockets and veins from narrow streaks up to 15 ft. wide, in gneiss, talc, chlorite and mica schists, in massive anthophyllite, and in olivine or serpentinized rocks. The mineral varies from white to almost black in color, being generally gray, pink, red and blue, sometimes green or brown, and often banded. Its color range, for a small area of distribution, is truly remarkable. Specimens with a beautiful chatoyant luster are not rare, but the varieties of corundum are seldom found sufficiently transparent for use as fine gems. Crystals are occasionally obtained weighing many hundreds of pounds. Corundum is liable to undergo an alteration, resulting in the formation of other mineral species, and accompanied by a reduction in its hardness and abrasive power. The chief minerals found with corundum are the following: Margarite, prochlorite, ripidolite, vermiculite, damourite, lepidomelane, pleonaste, hercynite, diaspore, cyanite, zoisite, fibrolite, tourmaline, actinolite, smaragdite, albite, steatite and kaolin. Closely associated with some of the corundum veins are deposits of large-plated mica and long-fibered asbestos.

As the special geological and mineralogical features of Corundum Hill are comparatively well known, more interest will attach to a brief description of the new and promising Sapphire district. The corundum mines of the Sapphire Valley Company are located in Jackson and Transylvania Counties, North Carolina, on the southeast slope of the Blue Ridge Mountains. They embrace the Socrates, Bad Creek, Sapphire, Whitewater, Brockton and Burnt Rock properties. These have been partly developed by open cuts, shallow shafts, tunnels and cross-cuts. The veins and pockets are from a few inches to 15 ft. wide. The "sand corundum" of the Socrates mine consists of white or gray corundum crystals about $\frac{1}{4}$ in. in diameter, imbedded in a matrix of decomposed chlorite and red clay. In this mine the vein is inclosed by walls of green chloritic schist, which gradually merges into a rock composed of radiately structured tremolite

and anthophyllite. This last-named rock extends from 150 to 300 ft. to each side of the corundum vein, and is bounded by a fine-grained granite or gneiss, which forms the usual country rock in this section. The vein material is said to average 15% corundum by a mill run.

At the Bad Creek mine the ore shows white, pink or blue corundum $\frac{1}{3}$ in. to 1 in. in diameter, imbedded in a gneiss consisting chiefly of black biotite or lepidomelane and chlorite, with feldspar, hornblende, tourmaline, quartz and garnet, associated with some pyrite, margarite, autunite, molybdenite, kaolin, talc and asbestos. The vein averages from 10% to 15% of corundum. Surrounding the vein is frequently found a "walling" of chlorite 1 to 2 ft. thick, and then about 4 ft. of hornblende schist, and beyond this, anthophyllite rock extending 120 to 180 ft. from either side of the vein to the country gneiss or granite.

Rich masses of corundum rock are found in the Sapphire mine. The pink or blue-stained corundum crystals are imbedded in a gangue of yellow decomposed mica and a fine-grained tourmaline gneiss. The Whitewater mine, 8 miles southwest of Sapphire, carries some highly crystallized and brilliantly colored corundum, of a decidedly resinous luster, besides much sand corundum. The mica here is decomposed and yellow, and occurs with white feldspar in various stages of alteration to kaolin. The Brockton mine, situated about 3 miles northeast of Sapphire, apparently consists of a series of pockets, in which are found very large dark-brown crystals of corundum. From a single pocket about 75 tons of clean corundum were taken. The occurrence is peculiar in that the corundum crystals are wrapped in decomposed feldspar and margarite, mixed with a small quantity of tourmaline. The Burnt Rock mine is located 8 miles northeast of Sapphire. The corundum is found imbedded in dark-green chlorite and decomposed yellow mica, and frequently occurs in large masses weighing from 25 to 50 lbs. The color of the corundum is mostly pure white, streaked with bands of deep-blue. Rarely, bronze-colored masses with a chatoyant luster are found. Besides the above property the Sapphire Valley Company owns the Edison mine at Acworth, in Paulding County, Georgia, 35 miles north of Atlanta. This mine is characterized by its beautiful blue and pink banded and striated corundum, occurring in large cleavable masses, together with a much decomposed feldspar, quartz and chlorite. Although this mine is only developed by a few shafts 25 ft. deep, it has produced several tons of corundum, including one of the most beautiful specimens of corundum ever mined, weighing nearly 100 lbs., which was exhibited in the Tiffany collection at the World's Fair. It is supposed that this variety of corundum contains a little water, or is undergoing alteration, as it is somewhat less hard and more easily cleavable than the common variety known as sand corundum, and readily turns white upon heating with the blowpipe. Within the last year emery has been discovered on Skeena Creek, 5 miles from Franklin, Macon County, North Carolina. This discovery has greatly stimulated prospecting in this region. The Fairview and Smoky mines are the best developed prospects. In both the ore is found to be more or less "pockety." It consists at the surface chiefly of hard emery rock, which continues 8 or 10 ft. down, and then pinches out or "runs into a flint seam," which may, however, lead to another vein-like pocket. The walls are decomposed chlorite, hornblende schist and talc schist or soapstone. In the emery veins are found masses of red

clay carrying sand corundum stained with manganese, into which the hard emery rock seems to merge in shallow depth. An indication of the proximity of the emery or corundum veins is float rock from them, often found near granite with coarse-plated mica, and decomposed schistose rock carrying much magnetite. The emery seems to consist of a mixture of rather fine-grained to medium coarse corundum and magnetite, associated with chlorite, hematite, quartz, mica, garnet and pyrite. A ton of emery has been shipped from the Fairview mine to be tested at Chester, Mass. Emery has also been reported as occurring at Cartoogaja Mountain.

Corundum Mills.—The concentrating mill at Sapphire is well adapted to the purpose of crushing and separating the corundum from the gangue, and has a capacity of 10 tons of clean corundum per 24 hours. This clean corundum was shipped as unfinished material in 100-lb. sacks by team 46 miles to Hendersonville, and thence north by rail to be finished, or refined, and put on the market. The first quality or coarse corundum was sold for 10c. per lb., and the second or finer-sized material for 7c. The production for 1892 was about 150 tons, for 1893 about 400 tons, and nothing in 1894, as the mill was idle. The Lucas mill at Cullasagee receives its power from a 40-horse-power turbine. The ore treated consists both of so-called rock corundum and sand corundum. The rock or lump corundum is carried to the mill by team, crushed in rock-breakers, and ground down to size No. 12. The principal ore—sand corundum—is sent down from the mines upon Corundum Hill in plank sluice-troughs a foot or two wide, a distance of 1½ miles, to the mill. There are three sets of washing troughs at the mill, the ore and water being turned upon any one or all three at once by means of sluice-gates with variable water feed. The pulp is fed to punched iron screens 3 ft. wide and 8 ft. long, with 7 or 8 holes to the linear inch. The "coarse" remaining on top of the sieve is reground in either vertical or horizontal steel rolls and in the screw mill—the object there being to break off the chlorite from the corundum—and rewashed. All that part going through the washing sieve is separated into three sizes, from No. 8 to No. 100 (the finest), dried in a furnace having a capacity of 20 tons in 24 hours, and shipped as unfinished corundum in sacks of 100 or 120 lbs. to Chester, Mass. Here it is sized more closely for the market. The maximum capacity of the above mill is 60 tons of ore, making not more than 20 tons of shipping corundum, as at least two-thirds of the ore is waste rock (chlorite and hornblende). Eight men are employed in the mill when running full capacity, and 30 men at the mines on Corundum Hill. Generally a load of 8 sacks per wagon is sent to Dillsboro or Sylvia and shipped from these towns by rail to Chester, where 8 or 10 grades of corundum are made, and the finished or refined product is put on the market. Dr. S. H. Lucas gives the production of the mill, which belongs to the Hampden Emery and Corundum Company, in 1893 as 304 tons, and the average price as 5c. per lb. When the corundum is below the sizes No. 60 or No. 70, it is sold for about 1c. less per lb. It is said that the Hampden Company will soon operate its new mill near Franklin, N. C.

Colorado.—The Salida corundum deposit is near the Calumet iron mine in Chaffee County, and on the land of the Colorado Fuel and Iron Company. But little is yet known as to the extent of the deposit, although a number of small

open cuts have demonstrated its continuity for at least 500 ft. in length and from 15 to 30 ft. in width. R. C. Hill states that a definite band of mica schist, through which are distributed numerous irregular bodies of corundum schist, containing an average of 40% of corundum, constitutes the lode. Nearly 400 tons of milling rock, from the prospect holes on the outcrop, is piled up on the ground. The mineral is in small blue and white tabular crystals, showing the basal and rhombohedral planes. The matrix is soft, easily crushed, and the impurities can be readily separated from the corundum by means of the ordinary jig and buddle. Ten tons of rock milled at Idaho Springs, Colo., yielded about four tons of product. Mr. Lucas of the Hampden Emery and Corundum Company, to whom a sample of this product was submitted, offered 5c. per lb. for the entire product of the mine in carload lots of that grade. Cement wheels made from this product by the Colorado Abrasive Company of Denver are declared to be of excellent quality. The Norton Emery Wheel Company is testing its adaptability for vitrified wheels. The company intends to thoroughly explore the deposit soon, and to erect a small concentrating mill for the treatment of the schist.

It is said that about 6000 tons of emery abrasive are yearly consumed in the United States, a large part in the loose form of powder. The market for corundum has been dull for the last two years; the manufacture of corundum wheels was therefore curtailed, and the mines and mill of the Sapphire Valley Company shut down. The manufacturers of emery wheels have been better able, by a combination, to withstand the general depression of trade. Emery now ranges, when sold in quantity, from about $45 to $76 per ton, while corundum is rated at from $60 to $200 per ton.

Infusorial Earth and Tripoli.

Infusorial Earth.—The localities where infusorial earth or "fossil flour" occurs or is mined in the United States were mentioned in The Mineral Industry, Vol. II., p. 2. Similar deposits occur in many other parts of the world, notably in Barbadoes, Sicily, Calabria, Greece, and the Nicobar Islands. The well-known "Barbadoes earth" consists mostly of these siliceous skeletons, but contains besides a variable proportion of the calcareous shells of foraminefera. This deposit rises to heights of more than 1000 ft. above the level of the sea, while that of the Nicobar Islands reaches an elevation of about 2000 ft. According to Haeckel, the eminent German naturalist, there are not less than 400 and there may be more than 500 species of polycystines in the Barbadoes earth, very many of which "are to-day extant and unchanged in the radiolarian ooze of the deep Pacific Ocean." In Bohemia there is a celebrated deposit of so-called tripoli (*Polirschiefer*), largely used as a polishing powder, which is composed almost entirely of the siliceous framework of diatoms. In the United States there are great deposits of diatomaceous earth near Richmond, Va., and Monterey, Cal. The former is about 30 ft. thick, and extends for more than 100 miles from north to south across the State, while the latter exceeds 50 ft. in thickness and is of unknown extent. All the beds noted above are of Tertiary age. In 1894 the production of "fossil flour" in Nova Scotia and prepared in Portland, Me., of infusorial earth (locally known as "tripoli") mined at Framing-

ham, Mass., and of so-called "silex" obtained at Hawleyville, Conn., aggregated about 750 tons, valued at a little less than $5400. The material was principally used in polishing metals and in finishing wood. The mines at Dunkirk, Calvert County, Md., and at Pope's Creek, Md., were not operated in 1894, owing to the small demand for infusorial earth.

Tripoli.—To the information contained in THE MINERAL INDUSTRY, Vol. II., we may add the following:

American "tripoli" is distinguished from "infusorial earth" by the mode of its origin, tripoli or siliceous earth being the porous silica left from a leached siliceous limestone, while infusorial earth, fossil flour, or diatomaceous earth, is of organic origin and consists of the siliceous skeletons of minute animals and plants (infusoria, polycystines and diatoms). Both tripoli and infusorial earth have approximately the same chemical composition, but seem to differ mineralogically, the latter probably consisting of opaline silica, and tripoli of chalcedony. The term "tripoli" was originally applied to an infusorial earth resembling clay or chalk in appearance, coming from the country of the same name in northern Africa. This material crumbles or powders easily between the fingers, while American tripoli has much greater cohesion. Tripoli is at present only extensively quarried at Seneca, Newton County, in southwestern Missouri. It seems to have been derived from the flint of the country rock (a cherty, lower carboniferous limestone) by some process of decomposition, which has left behind a very fine-grained porous material. According to O. H. Hovey,* the Newton deposit is known to underlie between 80 and 100 acres of land as a rude ellipse, with its longest diameter approximately north and south. Numerous prospect holes show that the bed is from 2 to 4 ft. below the surface of the ground, and that it varies from 10 to 25 ft. in thickness, with an average of about 15 ft. The main quarry of the company working these beds at present shows a section 18 ft. thick.

A well sunk in the northern part of the property gave the following section: Earth from the surface, 0 to 4 ft.; tripoli, 4 to 20 ft.; stiff red clay, 20 to 21½ ft.; mixed chert, clay and ocher, 21½ to 40 ft; cherty limestone, 40 to 93 ft.; cherty limestone bearing galenite, 93 to 103 ft.; limestone, 103 to 128 ft.; limestone bearing galenite and sphalerite, 128 to 136 ft.; soft magnesian limestone, 136 to 173 ft. The drill was lost in this soft rock at about 173 ft. The first 53 ft. of the well was sunk by digging, the remainder by using a 6-in. plunger drill. Not only is the bed of tripoli everywhere underlaid by a relatively thin stratum of very stiff red clay, but it is traversed in every direction by seams 1 to 2 in. thick of the same substance. The seams and other joints divide the rock into masses which vary in size up to 30 in. or more in diameter. In color the material varies from almost pure white, through a cream tint to a delicate rose, depending, probably, on the difference in the small amount of iron present.

The rock is very even in texture, and is so minutely porous that it forms a most excellent natural filter. For this purpose it is shaped into disks and cylinders, for use where gravity alone is to be depended on for forcing the water through the filters, and into thick-walled tubes for use under pressure. The

* *Scientific American Supplement*, July 28, 1894.

disks in actual use range from 4 in. to 20 in. in diameter, and the cylinders and tubes are from 2 in. by 3 in. to 12 by 20 in. in dimensions. Even larger sizes than these could be obtained if desired. The filters are very simple in operation, as they retain on the surface all the impurities of the water, and are cleaned by merely brushing them. They are rapidly coming into general use on account of their efficiency, cheapness and durability. On account of the great absorptive power of the rock, blotting pads have been made from it. When the surface of such a desk blotter becomes clogged by drying, it is easily cleaned by rubbing gently over it a piece of ordinary sandpaper.

A second and equally important branch of the tripoli industry is crushing the rock and grinding it into flour for use in polishing all kinds of metals, horn, shell, etc. The company grinds the rock in a common mill between burr-stones, and sifts it through two bolts of 70 to 120 mesh, similar to those used for bolting wheat flour. Last year the company sold 2,750,000 lbs. of this ground and bolted tripoli flour.

A portion was scraped off from a crude piece of the rock and mounted for the microscope. Examination with powers magnifying up to 450 diameters failed to show any remains of the skeletons of radiolarians or diatoms. The particles were extremely minute, by far the most of them being less than 0.01 mm. (0.0004 in.) in diameter, though an occasional grain measured 0.03 mm. across, and one was 0.05 mm. through. The particles are doubly refracting.

The following analysis was furnished the company by W. W. Seamon, professor of chemistry in the Missouri School of Mines, Rolla: Silica (SiO_2), 98.100%; alumina (Al_2O_3), 0.240%; iron oxide (Fe_2O_3 and FeO), 0.270%; lime (CaO), 0.184%; soda (Na_2O), 0.230%; water (ignition), 1.160%; organic matter, 0.008%—total, 100.192%. Silica soluble in a 10% solution of caustic soda, on boiling three hours, equals 7.28%.

The American Tripoli Company of Carthage, Mo., in 1893 produced from its mines at Seneca, Mo., 2,000,000 lbs. of ground tripoli, valued at $13,000, and in 1894, 2,750,000 lbs., valued at $18,500. The production of filtered goods (water filter disks, tubes, cylinders, etc.), was 20,000 pieces in 1893, valued at $12,000, and 30,000 pieces in 1894, valued at $17,000, besides 6,000 blotter rollers and pads, valued at $500, making a total value of $36,000.

ROUGE.

The polishing material known as rouge is really an abrasive and deserves at least passing notice. The rouge usually sold is made by dissolving iron in sulphuric acid, so as to form iron sulphate. This salt is heated and the sulphur driven off, leaving a residue of sesquioxide of iron, which, after washing, is known as rouge. But unsuitable iron and very impure acid is often used to form the sulphate, with the not unnatural result of producing poor rouges, of a very uncertain degree of fineness and quality. By a new patented process, the Pittsburgh Crushed Steel Company is converting steel directly into rouge, which is said to be of excellent quality.

Polishing a table of plate glass, of 250 sq. ft., requires, according to Mr. Kann, from 7 to 8 hours with the ordinary iron sulphate rouge, whereas the same work can be performed with this new steel rouge in from 4 to 5 hours, with a consumption of less than half the quantity of ordinary rouge required.

Steel Emery and Crushed Steel.

Within the last five years steel has been extensively applied as an abrasive in the form of "Crushed Steel" and "Steel Emery." These abrasives are manufactured preferably from pieces of high-grade crucible steel, heated to a temperature of about 2500° F. (almost a white heat), and then quenched in a bath of cold water, or other suitable hardening solution, which gives the steel a granular structure. The pieces are placed under powerful hammers or crushing machines, and reduced to small particles, varying from fine powder to grains of many different sizes. The steel particles are then tempered, preferably in the following way: They are placed in a cylinder or pan, and heated to a temperature of about 450° F., until the particles change their appearance to a straw color; they are then cooled by being subjected to cold air in various ways. The material at this stage, or before the tempering process, is graded into many sizes, according to the number of mesh openings of the sizing screen per sq. in. The sizes of crushed steel run in numbers from 6 to 90. Steel emery is similar to crushed steel, but is given an intensely hard temper, and its numbers range from 70 to 200 and above. These two abrasives, so closely related to each other, are used for entirely different purposes in the various trades.

According to Mr. Kann of the Pittsburg Crushed Steel Company, who has furnished the following information, steel ranks very close to the diamond in hardness, it being 9.27, if the diamond be taken as 10. Crushed steel is mostly tempered to a tough hardness, while steel emery, having different work to perform, is made intensely hard. A grain of steel, examined under a good magnifying glass, exhibits a series of sharp points and cutting angles. In work as fast as one point is worn down another is presented, while, should a grain break, it presents on the fractured faces a multitude of new cutting points. When a grain breaks in work it simply becomes two grains, and is thus, according to Mr. Kann, unlike all other abrasives which break down to a powder and generally become inert. These steel abrasives are now used in the sawing, rubbing and polishing of stone, marble, granite, onyx, etc., in lens grinding, glass beveling, brick grinding, and by lithographers, engineers and plate glass manufacturers. If a suitable bond could be found, so that this steel abrasive could be placed on the market in the form of a wheel, the length of the above list would be much extended. Experiments are being made with this end in view, and it seems to be probable now that the "Steel Abrasive Emery Wheel" will soon take its place as an article of commerce.

The stone trade consumes an important amount of crushed steel. The natural abrasive is, or rather was, sand. But sand, which breaks down under the pressure and impact of the saw blades or wheel, finally gave place to the chilled iron globules, better known as shot. Shot has in turn been compelled to give way to crushed steel. It simply became a question of cost and speed. Sand costs but very little, shot is costly, but crushed steel doubly so. Sand does the work but pulverizes, and therefore cuts slowly. Shot rolls, and so crushes the grains of stone, but steel, with its sharp edges, becomes for an instant imbedded in the soft blade, acts as a tooth, and cuts the stone in the same way as an ordinary saw cuts its way through wood.

The various sizes of crushed steel are used on different kinds of stone. Thus

the largest sizes, Nos. 10, 12, 14 and 16, are employed to saw stone of a coarse texture, such as the well-known Connecticut brownstone. The Indiana oölitic limestone is best cut with No. 30 or No. 36, while the finer textured stones, such as onyx and marble, require such sizes as No. 46 or No. 50. A small quantity of quicklime added to the crushed steel is said to prevent oxidation of the steel particles, and has been used to advantage in some of the large marble-cutting establishments in Knoxville, Tenn.

Crushed steel in core-drilling has taken the place of the diamond in many instances, and may eventually supplant it altogether. Sixty-five feet of a 1½-in. core of Lake Superior sandstone has been taken out in 10 hours with the use of No. 14 crushed steel, and one of the largest cores ever obtained was taken out with crushed steel from the Cleveland sandstone district, being 130 ft. in length and 6 in. in diameter. In practice the steel is fed alongside of a wrought-iron pipe, and by the use of water is brought under the revolving pipe, which acts as a bit, the steel taking the place of the diamond under the bit. What appears to be a practical and novel way of using steel in this particular instance is covered by a patent granted to Mr. J. Wyckoff, of Jacobsville, Mich., who takes a wrought-iron pipe 6 or 8 in. long and of a suitable diameter, and imbeds the grains of steel in the iron pipe by forcing the grains of steel into the heated metal by pressure, and then immersing the whole in a bath to bring back the original hardness. The inventor claims many advantages over the method of feeding the loose steel to the bit. In core drilling through a certain hard layer of rock, with the former method of using the loose steel only 4 ft. could be drilled in 10 hours, but by imbedding the particles of crushed steel in the bit, the same work was performed in half the time.

In rubbing down stone to a surface fit for receiving a polish, considerable care has to be exercised in selecting the proper size. This is governed largely by the surface left by the stone cutter. Some polishers take the stone to the machine direct from the pointing tool, others from the axe, and others from the 4, 6, or even 8-cut hammer. The finer the cut from the workman the smaller sized steel required. A serious mistake, however, is too often made by granite polishers. It has been the custom, from necessity, to bring a very heavy pressure to bear on the rubbing wheel. The formation of the grains of steel renders this great pressure unnecessary; in fact it is prejudicial, because it prevents rapid work. Grain emery was formerly very largely used by granite polishers. Now steel emery is chiefly employed, and a surprisingly small quantity will smooth down a stone, thus increasing the speed of production.

Lens grinders are finding out the advantage of using steel emery, both in speed and in cost. The abrasive is used over again so many times, and cuts so rapidly, that were it many times the price of emery it would still prove more economical. The cut always being uniform, the grinder knows just what surface each number will produce. For roughing-in, Nos. 70 or 90 are used, followed with No. 170 for fining down. Washed flour emery has hitherto been the smoothing medium, but the finest size of steel emery may advantageously be employed for this work.

In stone rubbing, glass beveling and brick grinding iron wheels revolved by power are used. For rubbing stone, a plate of 12 or 13 ft. diameter is used; in grinding brick, this size is reduced by one-half, and in glass beveling the ordinary

size is 30 in. But the process is the same in both cases. The steel is continually kept on the move. From the revolving bed or wheel the grains of steel drop into a circular trough, and are scraped out of this trough into a feed-box, from whence they are automatically fed to the center of the bed. By means of this device a small quantity of abrasive is in use, but every grain is always on the move, and is doing a large amount of work.

Steel emery No. 150 is taking the place of French sand used by lithographers in preparing the stone for work. One of the most important uses of this abrasive is in the grinding of plate glass. This was a process occupying about 7 or 8 hours, and necessitated the use of from 7 to 12 different sizes of abrasives. These may all be replaced by one or two sizes of steel emery, and the work can be turned out in from 3 to 4 hours.

Engineers are also finding the value of an abrasive which, Mr. Kann claims, "cuts but never breaks." In grinding metal, the work steel emery will do is considerable, and many of the repair shops of the leading railroads in the country have a place in their workroom for steel emery, using the sizes Nos. 150, 170, 190 and 200.

Mr. Kann states that hardened tool steel, against which emery instantly pulverizes, and which will resist the bite of a file, yields to the cutting power of these minute grains.

The production of crushed steel and steel emery in 1893 was 555,716 lbs., valued at $44,457, and in 1894 was 612,318 lbs., valued at $48,985.

PRODUCTION OF ABRASIVES IN THE UNITED STATES IN 1893 AND 1894.

Commercial Names.	1893.		1894.	
	Tons, 2000 lbs.	Value.	Tons, 2000 lbs.	Value.
Carborundum	8	$17,000	26	$55,000
Corundum and Emery	1,747	140,589	1,220	109,500
Garnet	1,520	55,800	1,000	35,000
Steel, crushed and emery	278	44,457	306	48,985
Tripoli(a)	1,351	25,625	1,801	36,687
Total	4,902	$283,471	4,353	$285,172

(a) Includes infusorial earth (so-called "Tripoli") of which 251 tons were mined in 1893, and 275 tons in 1894. Also embraces in 1893, 20,000 filters, discs, blotters, etc., worth $12,000; in 1894, 36,000 pieces, worth $17,500.

Corundum and Emery Mills.—The emery trade is practically controlled by three companies: 1. The Washington Mills Emery Company, at North Grafton, Mass. 2. The Ashland Emery Mills, at Perth Amboy, N. J., and 3. The Levant Emery Company, of New York, embracing the Walpole Emery Mills, at South Walpole, Mass., the Diamond Mills at Frankford (near Philadelphia), Pa., and the Jackson Mills, at Easton, Pa. All these concerns buy Turkish (Smyrna) emery ore, called Abbot stone, in distinction from Naxos emery, and sell the ground material principally to granite and plate-glass polishers. Only comparatively small quantities of Naxos emery are imported, and sold to wheel manufacturers. The cost of emery is about 5c. per pound, as against 2½c. for the impure material, falsely termed "American" emery, 250 tons of which were mined by the New York Emery Company at and near Peekskill, N. Y., in 1894. This latter is found in the eruptive rocks known as the Cortlandt series and occurs in several places in the town of Cortlandt, in Westchester County, New York. This so-called "American" emery is handled by the Tanite Company,

of Stroudsburg, Pa., and by the Levant Company, and sold principally to glass bevelers. The Levant Emery Company, besides the mills named above, includes the mills of the Hampden Emery and Corundum Company, at Chester, Mass., which last year shipped 475 tons of finished Naxos emery and 210 tons of corundum from the North Carolina and Georgia mines. The output of the Chester mine in 1894 was 725 tons of emery (corundum containing a small amount of iron).

The Sapphire Valley Corundum Company is now in the hands of receivers. Its mines at Sapphire produced much material that was not marketable, on account of the difficulty of separating the hornblende, etc., from the corundum.

Production.—The corundum ore mined in North Carolina and Georgia in 1894, produced 225 tons of refined corundum. The Colorado output in 1894 was 20 tons of finished corundum, while the Massachusetts production aggregated 725 tons of corundum-emery. Total: 970 tons of emery and corundum, valued at $97,000. Besides the above, 250 tons of so-called "American" emery, a mixture of magnetic iron, hornblende and other minerals, valued at $12,500, were produced in 1894.

Garnet.

Mr. F. J. H. Merrill writes that garnet is mined or quarried in New York State in places in and near the valley of the upper Hudson River in Warren County on the borders of the Adirondack region. It all appears to be of the common variety, almandite, and occurs in a formation of crystalline limestone, which appears to form the bed-rock of the valley in the vicinity of North Creek and Minerva and in gneissic rocks which adjoin or are intercalated with the crystalline limestone. It is found in segregated masses of varying sizes from that of a pigeon's egg to a diameter of 20 ft. It is commercially classified as massive garnet, shell garnet and pocket garnet, the former being impure from the admixture of other minerals. The shell garnet is almost entirely pure and the most valuable of the three classes named above for industrial purposes. The pocket garnet is that which occurs in small segregations or incipient crystals in the gneiss. Garnet is also found in Delaware County, Pennsylvania, where it is quarried under the name of "Rose" garnet by Herman Behr & Co., to the extent of about 1000 tons annually. It occurs there in small crystals thickly disseminated through a quartzose gneiss. There is also a deposit of garnet at Chester, Pa., which is worked to some extent. Large deposits of the mineral have been found in North Carolina, but its quality is not considered as satisfactory as that from the Adirondack region. Other deposits are said to occur in Georgia and Alaska, but no definite information can be obtained concerning them. Connecticut is also mentioned as a source of garnet. Garnet of the hessonite variety has been found in Phippsburg, Maine, but that locality has thus far only furnished a few fine specimens for jewelers' use.

This garnet is used almost exclusively in the manufacture of sandpaper, or garnet-paper, as it is called, which is employed extensively for abrasive purposes in the manufacture of boots and shoes. It is also employed to some extent in the wood-working industry. For metals garnet is not as good as emery, although some satisfactory results have been obtained from its use on brass. It

has been experimentally mixed with emery in the manufacture of emery-wheels, but without very satisfactory results. The firms quarrying and using garnet from the Adirondack region are H. H. Barton & Co., of Philadelphia, who control very extensive deposits there; Baeder, Adamson & Co., of Philadelphia; Herman Behr & Co., of New York, who also are interested in the deposits in Delaware County, Pennsylvania; Wiggin & Stevens, of Boston, who are also interested in the deposit at Chester, Pa.; the Boston Flint-paper Company, and the Union Sandpaper Company, of Boston.

In commercial use garnet is found to be harder, sharper and more lasting than quartz, and is preferred to it for certain kinds of work, although it costs about eight times as much as crushed quartz. The Adirondack garnet is said to be worth about $40 a ton at the railroad, although the average value of the mineral throughout the country is stated to be about $35. The superiority of garnet to quartz is probably due to the fact of its ready cleavage, which enables it to present, as it breaks away, new and sharp cutting edges, whereas the edges of the quartz grains, which have no cleavage, become dulled by friction. The only garnet now mined in the Adirondack region is the pocket garnet, which is used to make the better grade of garnet-paper. Some of the massive garnet has been used to make sandpaper for wood-working, and also mixed with corundum to make emery-wheels. The total production of Adirondack garnet in 1893 was about 432 tons, but this was much less than the usual output owing to the general stagnation of business and the small demand for garnet-paper. For several years previous to 1893 H. H. Barton & Co., are said to have mined from 800 to 1000 tons per year. In 1893 the shipments from North Creek amounted to 1475 tons. During 1894 almost nothing has been done in the mining and shipping of garnet. Only 294 tons were shipped from Warren County, New York.

William Hooper & Sons, of Ticonderoga, N. Y., have recently erected a mill near Minerva to crush the garnet-bearing rock and separate the garnet by water This, if successful, will to some extent revolutionize the garnet business, as many deposits not worth working by hand-sorting could be made to pay in this way.

Whetstones, Scythestones and Grindstones.

The following tables give the total production of whetstones, scythestones and grindstones in the United States for three years:

PRODUCTION OF WHETSTONES, SCYTHESTONES AND GRINDSTONES IN THE UNITED STATES.

Kind of Stone.	1892.		1893.		1894.	
Oilstones, etc.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Hindostan (finished product).....Pounds..	400,000	$12,000	300,000	$9,750	300,000	$9,000
Indiana sandstone (finished product).... " ..	150,000	3,000	150,000	3,375	150,000	3,375
Arkansas stone ("rough rock")..... " ..	40,000	1,600	50,000	2,000	100,000	4,000
Washita stone ("rough rock")..... " ..	500,000	6,250	400,000	5,000	250,000	3,125
Scythestones.						
New Hampshire (Indian Pond, etc).....Gross..	8,000	22,000	10,000	27,500	11,000	30,250
Vermont (Lamoille, etc.)..... " ..	5,000	17,500	4,000	14,000	4,700	16,450
Ohio and Michigan grit..... " ..	8,810	21,380	10,700	27,925	7,000	19,250
Grindstones.						
Ohio and Michigan.....Short tons..	.....	304,800	45,340	345,920	37,400	335 800

This table calls for no special remark. The only change to be noted is a decrease in the production of Washita stone, partly balanced by an increase in other brands.

ALUMINUM.

THIS metal was very fully treated in the articles published in THE MINERAL INDUSTRY, Vols. I. and II. To the information there given in relation to metallurgy there is little to be added. No new processes for the winning of the metal were developed during 1894; nor has the manufacture been extended on the scale which was hoped for at one time in the United States. The Pittsburg Reduction Company has continued to be the sole producer of the pure metal on a commercial scale, and this company reports from its present works an output of about one ton a day or 817,600 lbs. of practically pure metal during the year. This production will be considerably increased when the company's new works at Niagara Falls are in operation. These works are completed and will be started as soon as the Electric Power Company at the falls has finished the tests and is ready to furnish power from its dynamos. The new works will use about 5000 horse-power. Prices remained practically unchanged during the year 1894, but soon after its close a slight reduction was made.

No other works have been in operation during the year. The Cowles Electric Company has made no aluminum. The Wilson Aluminum Company, which began the construction of works at Spray, N. C., has been diverted from its original purpose to the making of calcium carbide, and the works have been converted with the intention of using them in that manufacture. There has been the usual amount of talk about new systems and new discoveries, but none have reached a practical stage.

The increase in the manufacture of this metal in Europe has been somewhat greater than in this country. The improvements and additions to the works of the Aluminum Industrie Gesellschaft at Neuhausen in Switzerland have enabled that company to increase its output from 438,000 kilos, valued at 2,400,000f., in 1893 to 600,000 kilos, valued at 3,000,000f., in 1894. The company has very nearly reached in its production the limits of the power available at Neuhausen and for an increase in output is looking elsewhere. The Société Electro-Metallurgique de Froges, France, which has been working quietly for some time past, and produced in 1893 a total of 137 metric tons of metallic aluminum, valued at 974,000f., in 1894 made about the same amount. Toward the end of the year it completed arrangements for a considerable enlargement of its plant, and the stockholders have authorized an issue of 3,200,000f. in new capital. The larger part of this has been taken by the Neuhausen Company, which will thus control the manufacture of the metal at Froges from the bauxite deposits of the Isère as well as that from its own works. The Société Electro-Metallurgique has also voted to con-

solidate with the Société Française de L'Alumine Pure, so that the business in France will be under the management of a single concern, and the Neuhausen Company will practically control the manufacture of this metal in Europe, for a time at least.

We have to note also, near the close of the year, the organization of a new company in England, known as the British Aluminum Company, Limited, with a capital stock of £300,000. This company intends to work under the same process that is used at Neuhausen and Froges and has also purchased some British patents from other parties. The source of supply of its works will be the bauxite deposits of Ireland, and several beds of that mineral have been secured for the company, which has announced its intention of building extensive works. We are not informed, however, that these works have yet been begun or even that it has been decided where they shall be erected.

With regard to the use of the metal perhaps the most important event to be noted during the year was the construction of a second-class torpedo boat for the French government by Yarrow & Company of London. This boat was of aluminum bronze, the alloy used containing 94% aluminum and 6% copper. The dimensions of the boat were 60 ft. in length and 9 ft. 3 in. beam. The propelling machinery consists of a triple expansion high-speed engine, fed with steam from a Yarrow water-tube boiler. The total weight of the hull and machinery with the water in the boiler is 21,000 lbs., and the weight of the hull alone is two tons. The hull of a similar boat made of steel weighs on an average four tons, and in none of the same class has it been possible to obtain a greater speed than 17 knots heretofore, while 20.5 knots were reached with this boat. As compared with the steel boats the scantling has been thickened about 25% all through. The tensile strength of the alloy is 14 tons to the square inch, and its elastic limit is very high. The price of the various constructional parts varied from 72c. to $1.20 per lb. These figures are somewhat general in character, and several items of interest are omitted. For obvious reasons the builders and the owners of the vessel did not care to publish too detailed an account of their new departure. Generally speaking, however, it seems clear that the increase in the framing greatly increases the rigidity of the structure, and this, together with the superior physical characteristics of the alloy, enabled the builders to submit the boat to an extra driving strain corresponding to 3½ knots more than a similar boat built of steel. These boats are intended to be carried on battle-ships and cruisers, and any decrease in the weight is of great importance. Near the end of the year the French Ministry of Marine gave an order for 42,000 kilos of aluminum for use in naval construction; it is understood that steam launches and small torpedo-boats will be built of aluminum bronze. This order is a notable one from the fact that it is the largest order for the metal ever given at one time.

It will be seen, however, from this account that the cost of the aluminum bronze is still too high to make the metal available for general use. It is understood that this alloy is to be used in some new racing yachts; here also the cost is not an object as compared with the lightness and smoothness of surface which can be attained in the hull with this metal.

For minor purposes, as, for instance, in culinary utensils, aluminum is being

gradually brought into use in this country, but it is here still handicapped by the high price of the metal. For small articles and ornaments its use is also extending largely, since for these the quantity of metal required is much smaller and the workmanship forms a higher proportion of the value of the finished product. Moreover, these articles have to come in competition with silver or silver-plated goods, which are still more costly, and not with the cheaper tin plate and iron as in the case of kitchen ware. The quantity used for these articles, however, is still small in total amount, although the number manufactured and sold is continually increasing. On the other hand, in some of the smaller uses for the metal there has been a decrease; in carriage and saddlery hardware, for instance, aluminum bronze, which was tried with some success, has failed to replace the silver and nickel-plated trimmings, and some large manufacturing firms report a decrease in their consumption of the new alloy. Upon the whole, however, it may be said that the use of aluminum is extending, and can be extended at a much more rapid rate whenever manufacturers can be supplied with the metal at a price which will bring it fairly into competition with others.

Trials of the metal for military accouterments are in progress in the French and Russian armies; in these cases its lightness is the advantage sought. A trial was made in the Russian cavalry of aluminum horseshoes, but it is stated that the results were not satisfactory.

One notable use to which aluminum has been applied during the year has been the plating of large iron columns for the public buildings in Philadelphia. This work was done by the Tacony Metal Company and the process is fully described in the article on electroplating in this volume.

The prices of the metal in the United States during the year being fixed by the Pittsburg Company remained practically unchanged. They were for No. 1 metal, which is over 98% pure, from 58c. to 63c. per lb., according to the size of order, for ingots ready for rolling, and 53c. to 60c. per lb. in ingots for remelting. For No. 2 metal, which is over 94% pure, the price charged was from 50c. to 55c. per lb., according to the size of the order, for ingots ready for remelting. In both cases the highest price quoted was for lots under 100 lbs. and the lowest for orders of one ton or over. The company also furnished the metal in finished forms, quoting rolled sheets from 80c. upward per lb., according to the size and thickness; wire from $1 upward according to gauge, and castings from 90c. per lb. upward. Just after the close of the year a new price list was issued making reductions of from 2c. to 4c. per lb. in the quotations for ingots.

In Europe the prices throughout the year were practically established by the Neuhausen Company, which on January 1st announced a reduction to 5f. per kilo at the works for small orders; this price is equivalent to 45c. per lb. The price quoted is for No. 1 metal, which is guaranteed 98% pure, and in fact generally runs over 99%. No change was made throughout the year. The company makes a discount of from 10% to 20% on large orders. The quotations on the Paris metal market showed, like those of the manufacturers, no change throughout the year, remaining steady at 5@6f. per kilo for ingots, according to the size of the order, 8f. per kilo and upward for sheets, and 19f. per kilo and upward for tubes. A reduction in the price has been promised, but has not yet been made. It will be seen that the Neuhausen Company's price is considerably below that charged in this country.

The following table shows the production and imports of aluminum in the United States for five years, ending with 1894, the sum of the two giving the estimated amount of the consumption of the metal:

PRODUCTION, IMPORTS AND CONSUMPTION OF ALUMINUM IN THE UNITED STATES.

Year.	Production.		Imports.		Consumption.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1890.....	61,281	$61,281	2,051	$7,062	63,332	$68,343
1891.....	168,075	126,056	3,922	6,266	171,997	132,322
1892.....	295,000	191,750	43	51	295,043	191,801
1893.....	312,000	202,800	7,816	4,683	319,816	207,483
1894.....	817,600	490,560	5,303	2,524	822,903	493,084

The figures for production include the aluminum used in alloys.

As stated above, Switzerland is now the largest producer of the metal, its output last year having been 600,000 kilos, or about 50% more than our own. The French production is at present about 100,000 kilos annually, with a prospect of an increase in the near future. The German production, which at one time was the largest, is now comparatively small.

The total output of metallic aluminum in the world during 1894 may be estimated at 1100 metric tons, of which the United States furnished about one-third. This production compares with an estimated total of 675 metric tons in 1893 and 500 tons in 1892. While the figures do not seem large, it must be remembered that the industry has grown up within comparatively a few years and under many difficulties, and that ten years ago, in 1885, the entire cutput of the metal was but a little over three tons. Aluminum has emerged from the position which it occupied for a number of years as simply a curiosity or a production of the laboratory to take an established part in the commerce of the world as a material of industry, and that position will undoubtedly become better and better established as improvements in the manufacture make it possible to reduce the price.

A considerable increase in production may be expected during the current year and the manufacture will certainly be much further developed in 1896, when the full effect of the enlargement of the Neuhausen and Froges Works in Europe and of the new Niagara Works in this country will be felt.

ALUM AND SULPHATE OF ALUMINA.

By John Enequist.

When the term alum is used the crystallized potash or ammonia-alum is generally meant. These are, chemically speaking, the double sulphates of alumina and the alkalies named. The word alum is, however, also used to denote what is properly sulphate of alumina alone without any combination with an alkali sulphate. The reason for this incorrect use of the word is that the crystal alums are being gradually replaced by the cheaper and more efficient sulphate of alumina, which is the only active ingredient in the ordinary kinds of alum, and would before this have taken their place had it not been for the difficulties met with in attempting to produce it in a pure state. Owing to its impurities, chiefly iron and free acid, consumers objected to it and preferred to buy the alums as crystals, which could readily be obtained sufficiently pure, and therefore easily held their ground against their competitor in spite of the fact that in using them their most expensive ingredient—the potash or the ammonia—was wasted. The manufacture of sulphate of alumina is therefore of comparatively recent origin, but has already assumed very large proportions. It will probably in time take the place in the arts of the common alum altogether, and will then presumably be known as alum, thus robbing the crystallized product of its original name.

Natural Sulphate of Alumina occurs as natural hydrated salt in the shape of alunogen, halotrichite or hairsalt. Below we give analyses of a few of the pure deposits, none of which are large enough to be of commercial importance :

	1	2	3	4	5	6	7
Al_2O_3	11.23	12.78	16.15	15.57	14.98	16.000	15.40
SO_3	35.64	35.71	34.90	35.82	35.68	36.400	36.05
FeO	0.72	0.67	.....	.....	.....	0.004	.....
MnO	0.31	1.02	.....	.....	.....	.....	.....
K_2O	0.43	0.32	.....	.....	.....	.....	.....
Na_2O	.....	.....	.....	.....	.....	.....	.....
CaO	0.45	0.64	.....	.....	.....	0.002	.....
MgO	1.91	0.27	.....	.....	.....	0.004	.....
SiO_2	0.43	.....	.....	.....	.....	.....	.....
H_2O	48.85	47.02	48.95	48.61	49.34	46.600	48.55
	99.97	98.43	100.00	100.00	100.00	99.010	100.00

Nos. 1 and 2 are taken from Rammelsberg's *Mineral chemie* and represent minerals from Freienwalde and Potschappel, near Dresden, Germany. Nos. 3

and 4 are Bohemian minerals, according to Rammelsberg. Nos. 5 and 6 are from Saldaño Pasto, Colombia, and No. 7 represents the composition of the pure crystallized salt: Al_2O_3, 3 SO_3+18 H_2O.

Several basic sulphates also occur in nature, of which alunite is the most important. This is treated below among the raw materials for alum manufacture. Of other natural basic sulphates we will only mention aluminite found at Mühlhausen, in Bohemia, and corresponding to the formula Al_2O_3, SO_3+9 H_2O.

Potash alum: K_2O_3, SO_3+Al_2O_3, 3 SO_2+24 H_2O, occurs as kalinite as an efflorescence on aluminous minerals at Whitby, Yorkshire, England; Campsie, Scotland, etc. In several places in Italy, on the islands of Milo and Volcano, and in Solfatara and other places on volcanic ground potash-alum is found in larger amounts. It is there formed by the action of sulphurous acid vapors upon the felspathic trachyte, the acid combining under the influence of the atmospheric oxygen with the potash (K_2O) and alumina (Al_2O_3) in the feldspar to form alum.

RAW MATERIAL OF ALUM MANUFACTURE.

1. *Bauxite.*—This mineral is a hydrated oxide of alumina mixed with various amounts of ferric oxide (Fe_2O_3) and silicic acid (SiO_2), of which the former takes the place of an equivalent amount of alumina (Al_2O_3), and the silicic acid occurs either free or combined with alumina. Of bauxite we may distinguish three different kinds: The monohydrate (Al_2O_3, H_2O) the double hydrate (Al_2O_4, 2 H_2O), and the triple hydrate (Al_2O_3, 3 H_2O). Of these the monohydrate constitutes the mineral diaspore, the triple hydrate the mineral gibbsite. The composition of the bauxite varies from that of the mineral diaspore with 85.12% alumina (Al_2O_3) and 14.88% water (H_2O) to that of the gibbsite with 65.61% alumina (Al_2O_3) and 34.39% water (H_2O). Knowing that the elements in nature combine according to certain invariable proportions with each other to form the different minerals it should be possible in every instance to trace any given kind of bauxite, of known composition, down to a certain chemical formula; that is, each bauxite ought to correspond to a certain hydrate of alumina. In finding this hydrate we are somewhat hampered by the impurities. But if we remember that, as stated above, the ferric oxide simply takes the place of its equivalent of alumina, and that the silicic acid in the French and Irish bauxites occurs chiefly in combination with alumina as Al_2O_3, 3 SiO_2, the three equivalents of silica or 180 lbs. SiO_2, taking the place of 3 H_2O or 54 lbs. H_2O, while in the American varieties the silica appears to occur as free SiO_2, it becomes comparatively easy to trace any bauxite down to one of the following formulas:

	Composition in Per Cent.		Corresp. Mineral.
Al_2O_3, 3 H_2O	65.61 Al_2O_3	34.39 H_2O	Gibbsite
2 Al_2O_3, 5 H_2O	69.85 "	30.15 "	
Al_2O_3, 2 H_2O	74.10 "	25.90 "	
2 Al_2O_3, 3 H_2O	79.61 "	20.39 "	
Al_2O_3, H_2O	85.12 "	14.88 "	Diaspore

Taking the analyses of bauxites as given in THE MINERAL INDUSTRY, Vol. II., pp. 61–62, we thus find that the French bauxites correspond to the formula Al_2O_3, H_2O, while the American minerals are chiefly the triple hydrate. We need not add that in attempting to trace the structure of a certain kind of

bauxite from its analysis it is absolutely necessary that "water" given in the chemist's report should not include moisture, but should mean combined water; that is, the analysis should be made on a dry basis.

That the silicic acid occurs in another form in the French and Irish than in the American bauxites becomes apparent when treating them on a large scale with sulphuric acid, for we then find that the latter dissolve much more quickly than the European kinds, showing at once that the alumina in the American bauxites occurs in a more basic condition than in the foreign varieties.

The European bauxites are generally high in iron, particularly in the case of the so-called red bauxites. The light-colored or white bauxites contain less iron and approach more nearly to the American kinds. Of these, several of the Georgia and some of the Alabama deposits are distinguished for their freedom from iron, and become on that account especially well-suited for the manufacture of alum.

As to color, appearance, texture, analyses, occurrence and mining of bauxite, we must refer to the article on this subject in Vols. I. and II. of THE MINERAL INDUSTRY.

Alunite.—The mineral occurs at various places in Italy and Hungary in volcanic ground. The largest Italian deposit is at Tolfa, near Civita Vecchia, in the Roman States. There is another at Solfatara, near Naples. These deposits are formed by the action of sulphurous acid and steam upon trachyte and are found both in the amorphous and crystallized state in strata of quartz. It is in the hollows of the quartz that the alunite crystals occur. An alunite of a different formation occurs at Puy de Garcay, Auvergne, where the mineral appears to owe its origin to the oxidation of iron pyrites present in the clay.

Alunite consists of a basic potassium-aluminum sulphate and may be considered as an alum holding a large excess of alumina. The Tolfa variety holds 17½% to 32% alumina. The average composition of the crude article from Tolfa is given by Guyot as 27.6% Al_2O_3; 29.74% SO_3; 7.55 % K_2O; 1.20% F_2O_3; 22.70% SiO_2 and 11.20% H_2O. The crystals contain, according to Cordier, 39.6% Al_2O_3; 35.5% SO_3; 10.0% K_2O and 14.9% H_2O.

From this we arrive at the formula:

$$2\ (K_2O,\ SO_3+Al_2O_3,\ 3\ SO_3)+5\ (Al_2O_3,\ 3\ H_2O)$$

or the simpler $K_2O,\ SO_3+Al_2O_3,\ 3\ SO_3+3\ (Al_2O_3,\ 3\ H_2O)$ which is given by Rammelsberg.

Roscoe and Schorlemmer give this formula:

$$K_2O,\ SO_3+Al_2O_3,\ 3\ SO_3+2\ (Al_2O_3,\ 3\ H_2O).$$

The amorphous alunite is a mixture of the mineral with quartz and clay, as shown by the above analysis by Guyot. The only analysis of Hungarian alunite seen by the writer gives 17.5% Al_2O_3, 12.5% SO_3, 1.0% K_2O, 62.2% SiO_2 and 5% H_2O. A large deposit of an excellent quality of alunite occurs at Gloucester, New South Wales, and is said to yield an alum perfectly free from iron.

Alunite is insoluble in water in its crude state. When roasted at the proper temperature, the basic sulphates change, the bond existing between the neutral sulphate of alumina and the hydrate of alumina is broken and water is able to extract sulphate of alumina from the mineral. If the heat is raised too high, a

further decomposition sets in, oxygen and sulphurous acid are given off and alumina mixed with insoluble sulphate of alumina is left behind; even the sulphate of potash present is attacked, so that K_2O combines with SiO_2 and Al_2O_3; and the mineral becomes valueless.

Aluminous Earth and Alum Shale or Alum Schist.—The former of these materials occurs mixed with and surrounded by lignite in strata in several places in Germany. It consists of a mixture of clay and finely divided iron pyrites, easily broken up and of a dark color. In its natural state it contains no sulphates as such, but exposure to the air causes a liberal formation of such salts, induced by the oxidation of pyrites (FeS_2) to ferric sulphate and free sulphuric acid, which attacks the clay and forms sulphate of alumina. When heated without access of air it generates an inflammable oil and separates sublimed sulphur. Heated with access of air it burns with evolution of sulphurous acid and a brick-colored clay is left.

Alum Shale (*Schist*) occurs in large deposits at Whitby in Yorkshire, England, at Hurlet and Campsie, Scotland, in many places in Sweden, in Bavaria, Prussia, Saxony, Bohemia and Belgium. It is a mixture of aluminum silicate (clay) with iron pyrites strongly colored by carbonaceous matter. It is often found alongside of coal beds. The following analyses, by Richardson and Ronalds, show the composition of: 1. Whitby top rock; 2. Whitby bottom rock; 3 and 4. Campsie top rock; 5. Campsie bottom rock.

	1	2	3	4	5
Pyrites (FeS_2)	4.20	8.50	41.52	38.48	9.63
SiO_2	52.25	51.16	15.40	15.40	47.00
FeO	8.49	6.11	.....	.....	2.18
Al_2O_3	18.75	18.30	11.35	11.64	18.91
CaO	1.25	2.15	1.40	2.22	0.40
MgO	0.91	0.90	0.50	0.32	2.17
MnO_2	.....	.....	0.15	.....	0.55
SO_3	1.37	2.50	.....	.....	0 05
K_2O and Na_2O	0.33	Trace	0.90	.....	1.47
Coal	4.97	8.29	.....	.....	.....
Carbon and loss	.....	.....	29.78	31.93	9.10
H_2O	2.88	2.00	.....	.....	8.54

Alum shale is generally so rich in bitumen that it can support its own combustion (the Campsie shale is too rich to be roasted by itself, and has to be mixed with spent rock to prevent too high a rise in temperature). In some varieties so much finely divided feldspar is present that a further addition of potash (K_2O) becomes unnecessary. This is particularly the case in Sweden, where up to a very recent date no other raw material for alum manufacture was used. When burned the color of the shale changes to red. It is much harder than the aluminous earth, but its composition is substantially the same.

Of the *other aluminous minerals*, more or less fit for alum manufacture, such as kaolin, clays rich in alumina, feldspar (leucite and ortoclase), cryolite, etc., we cannot treat here; all these minerals are described under their own headings in previous volumes of THE MINERAL INDUSTRY. A very pure sulphate of alumina, free from iron, is produced from the cryolite. The other minerals have been superseded by bauxite.

SULPHATE OF ALUMINA.

Composition and Properties.—Neutral anhydrous sulphate of alumina (Al_2O_3, 3 SO_3) consists of 30.03% alumina (Al_2O_3) and 69.97% sulphuric acid (SO_3); the crystallized and hydrated salt (Al_2O_3, 3 SO_3+18 H_2O) consists of 15.44% alumina, 35.98% sulphuric acid, and 48.58% water. This is also the average composition of the ordinary trade article, although this latter generally contains some iron and other impurities and is seldom exactly neutral, containing an excess of either free acid or alumina.

The neutral sulphate can combine with more alumina and form two basic salts: 2 Al_2O_3, 3 SO_3, which is soluble in water and Al_2O_3, SO_3 (3 Al_2O_3, 3 SO_3) which is insoluble and is formed by boiling or diluting a solution of the former. Combined with 9 H_2O, the sulphate of alumina (Al_2O_3, SO_3) forms aluminite, as we have seen.

The neutral salt with 18 mol. water crystallizes in thin leaves. According to P. Margueritte-Delacharlonny, there exists also a salt with 16 mol. water. He attempts to prove by experimental work and from analyses of certain South American deposits of natural sulphate that the salt with 16 mol. water is the normal salt. This salt should contain 16.32% alumina (Al_2O_3), 38.08% sulphuric acid (SO_3) and 45.60% water (H_2O). There is at Rio Saldaña, Colombia, a deposit that analyzes 16.10% alumina (Al_2O_3), 38.43% sulphuric acid (SO_3) and 45.47% water (H_2O). As several of the other deposits approximate the generally accepted formula just as closely (see table of analyses above), the existence of the salt with 16 mol. water is not proven. Some of this scientist's artificially prepared salts correspond much more closely to a formula with 15 H_2O than to one with 16 H_2O.

The crystallized sulphate dissolves in one-half its own weight of cold water, but is nearly insoluble in alcohol. When heated it melts or dissolves in its water of crystallization, and if now allowed to solidify it will form the ordinary alum-cake or concentrated alum. If the melted salt be heated further, it swells up to a porous mass of anhydrous sulphate, upon which water, either hot or cold, has very little effect; only long continued boiling will bring it in solution again. When heated to redness the aluminum sulphate is decomposed with formation of alumina, sulphurous acid and oxygen.

Sulphate of alumina in any form, whether acid, neutral or basic, acts upon metals of the iron group like an acid; it dissolves aluminum, iron, zinc, etc., and can be made more basic by such treatment. Hydrogen is evolved and this fact can be made the means of producing a very porous alum, about which more will be said further on.

MANUFACTURE OF SULPHATE OF ALUMINA FROM BAUXITE.

1. *By the Sulphuric Acid Method.*—For this purpose we want a mineral as high in alumina and as low in iron and moisture as possible; the percentage of silicic acid is of minor consequence.

The bauxite is first ground in a low-speed mill; it has been found that the mineral when ground in a high-speed mill is not acted upon by sulphuric acid in as satisfactory a manner. This observation was made particularly upon

French bauxites. As to the American kinds, which are much softer and more easily attacked, this observation will probably not hold good. A suitable mill for grinding any kind of bauxite is a well-constructed chaser mill, such as the Carlin dry-pan. Another mill that is doing good work on bauxite is the lately introduced Griffin mill, which imitates as nearly as possible ordinary hand grinding done in a mortar. The pestle or "roll" in this mill makes 200 revolutions around the sides of the mortar or the "ring," so that it is a high-speed mill.

A 6-ft. Carlin dry-pan, when working at say 30 revolutions, and discharging through ⅛-in. slots in the plates on the bottom of the pan and generally worked on the maker's plan, will deliver 1000 lbs. of 30-mesh material per hour. When properly geared, it should not require over 20 to 25 horse-power. About 30-mesh is a fineness experience has shown to be satisfactory and economical in the case of French bauxites; 20-mesh is fine enough for the American mineral. A larger dry-pan will do comparatively more work per horse-power expended, but very few works use even as much as 10,000 lbs. per day, and therefore a 6-ft. pan is ample for ordinary purposes. As, however, sulphate of alumina can also be ground advantageously in this mill, it is better economy to use a larger size and employ it for both the raw material and the finished product, taking care to have a large quantity to grind of each kind every time, so as to minimize the labor of cleaning out the mill.

For dissolving the ground bauxite in the sulphuric acid, a round or square tank is used, which is lined with 8-lb. lead on the sides and 10-lb. lead on the bottom. This tank is provided with a closed steam coil resting on the bottom, also with an open steam-pipe that can be raised or lowered at will and terminates in four branches each 3 in. long and suitably perforated for the distribution of the steam all through the contents of the tank. There are also pipes for the introduction of hot and cold water, chamber acid and weak alum liquors. The capacity of the dissolver or mixer should be four to five times the volume occupied by the materials introduced, in order to allow proper foaming space.

When working bauxite for sulphate of alumina, we aim to obtain a neutral or slightly basic product and must adjust the proportions between acid and bauxite accordingly. The percentage of alumina contained and the nature of the mineral and its cost must determine what proportion of acid (H_2SO_4) should be used. Preliminary laboratory tests are necessary to decide this in each case.

For a charge of 1250 lbs. of bauxite and its complement of chamber acid, a tank 9 ft. in diameter and 4 ft. high is used; for the closed steam-pipe on the bottom, 60 ft. of heavy 1-in. lead pipe are sufficient. The open steam-pipe is made of the same material the full height of the tank and is provided with a swivel arrangement enabling the workman to raise it when not in use and blow out any deposit from the perforations in the end branches. Care should be taken to use only dry steam in this pipe so as to guard against undue dilution.

The dissolving process is as follows: The chamber acid (sulphuric acid 50° Baumé. or 1.526 sp. gr., holding 62.18% H_2SO_4 or 50.75% SO_3) is run in the mixer in the evening on top of the undissolved residue left from a previous operation; is heated by means of the open steam-pipe to 190° to 200° F. and thoroughly agitated with the residue. The contents are then left with steam shut off, until

next morning, when the mixture is again heated to 200° in the case of French or Irish bauxite, and in the case of American mineral to only 100° F. The steam is shut off and the strength of the mixture reduced to 43 or 44° Baumé, tested at its own heat. The ground material is now shoveled in, taking care to distribute it as evenly as possible. According to the nature of the bauxite, we may put in all the bauxite at once or divide the charge in two or three portions. Of a soft mineral, rich in alumina, it is best to add at the start only one-fourth to one-third of the whole charge, allowing the first violent reaction, which sets in in a few minutes, to exhaust itself somewhat before adding the second lot and so forth. If this precaution is not taken, large losses may be caused by the contents boiling over. In the case of hard bauxites, holding more or less silicate of alumina and therefore more refractory, the whole charge may be shoveled into the hot acid at once and stirred up with it, and the whole then left at rest. Unless the acid is heated to too high a degree, which is prejudicial to a good yield, the reaction will not take place until 15 or 20 or even 30 minutes have elapsed, and will not be so sudden as in the case of American bauxites. Still it is necessary, no matter which material is used, to have either weak sulphate of alumina liquors or cold water in readiness to let down, preferably in a spray, upon the foaming mass, to prevent the same from running over the sides of the tank. No more of the spray should be used than absolutely necessary as it helps to check the reaction. The importance of a large foaming space is therefore readily understood. After one to two hours, the mass has settled down and is covered on top by a crust of very porous solid sulphate of alumina, easily soluble in water. We may now pursue either one of two methods. The first one is to leave the charge to itself from three to four hours without disturbing it. The crust will then prevent the mass from cooling and the reaction will proceed slowly underneath and complete itself if sufficient time is given; with enough of Al_2O_3 present, the H_2SO_4 will ultimately be all converted into Al_2O_3, $3\,SO_3$ and sometimes even a basic liquor, indicated by a reddish color, be produced. We need not state that the finer the bauxite has been ground the quicker and more satisfactory is the result. In this case we have sacrificed some alumina for the sake of getting back all our acid.

If we desire to extract all the alumina from the bauxite, counting it of more value than the acid, it will be better to wait until no more bubbles of escaping steam or any other signs of a further reaction appear, and then heat the mass either by the coil or the open steam-pipe under frequent agitation until the chemical test shows that all the available alumina is dissolved. By "available" alumina we mean here all that laboratory tests have shown and practical experience has taught can be extracted in a day's work with a certain weight and strength of sulphuric acid. No matter which of the methods is used, some alumina in the shape of unattacked bauxite will always remain in the dissolver or mixer. By using a sufficient excess of acid and employing enough steam and labor, we can reduce this residue to a minimum, but the expense would be too great and we would find that what extra alumina we gained by a more complete decomposition of our charge, we lost in another form, for in order to reach the result aimed at we would have had to heat the charge for a long time and in so doing concentrate the mass until some of the sulphate of alumina separated as anhydrous salt, which, as stated above, is very difficult to bring in solution

again. (There is also a formation of basic salt if the liquid is not well agitated.) Such separation takes place around the closed steam coil to some extent, even in ordinary working, owing to overheating of the liquid in contact with the pipe, and if the concentration is driven too far, complete solidification may set in. In such case the whole mass has to be taken out with pick and bar. The coil should therefore not be used more than necessary, and if, owing to one cause or another, the mix has not been successful but extra heating has had to be resorted to to insure a proper neutralization of the acid, it is best to run in a little water continuously to make up for the amount passing off as steam. At the same time the attendant must try from time to time the consistency of the mass and see that it does not get too thick.

It is sometimes necessary to add finely ground bauxite or even lime toward the end when all other means have failed to produce neutral liquor. If lime is used it should be in the shape of a very fine slacked powder and be sprinkled over the surface with constant stirring, otherwise great balls of hydrated oxide of alumina will form which will be found very troublesome to redissolve. A chemical test of the liquor is required to determine its neutral condition, but the practiced workman is able to tell from the color of the mass when all the acid is neutralized; the color then has a suggestion of yellowish red in it that is not there as long as free acid is present.

It is readily seen that the coil on the bottom of the mixer is an objectionable construction, as it interferes with the stirring and often gets coated with solid matter, thus becoming inoperative and a source of great waste of fuel. The better plan is to have a double bottom in the mixer, and to use a $\frac{1}{4}$-in. thick circle of wrought iron, which must be well supported and placed $\frac{3}{4}$ in. from the lead-lined tank bottom. The upper side of this sheet of iron must, of course, be covered by a piece of sheet lead well dressed down and burned to the sides of the tank. The steam is admitted into this $\frac{3}{4}$ in. space, when it is desired to heat the charge, and damage from leakage from above is provided against by having a 2-in. pipe, provided with a suitable valve in the middle of the real tank bottom, which is made to slope from the sides toward the center. With this construction we are also able to more easily clean the mixers, which has to be done about once every week.

A comparison of the two treatments mentioned above will show us that the relative cost of the materials must determine the choice. As long as alumina is cheaper than its equivalent (3 SO_3) of sulphuric acid, the first method is preferable, but under opposite conditions, that is, with very expensive alumina, the latter may be more economical. Although the second method might appear more rational there are many objections to it: it requires more steam and labor and a large loss of both alumina and acid in the shape of nearly insoluble sulphate of alumina may result. It is under all conditions an expensive method, and as a rule it may be said that the other treatment is preferable. After trying both methods carefully the writer found that a much greater amount of alumina could be extracted by the second treatment—thus it was possible to use to 1250 lbs. French bauxite, holding 66% alumina and 3.2% ferric oxide, equivalent to say 850 lbs. alumina, an amount of chamber acid corresponding to 1864 lbs., SO_3, equivalent to 799 lbs. alumina, and still obtain a neutral liquor, which shows that

only 6% of all the alumina present was left undissolved—but it was also found that the increase in yield of finished product fell materially short of expectations, that consequently sulphate of alumina was lost in the settling mud (see below). This may be largely obviated by running in more water during the steaming and agitation, thus keeping all the sulphate of alumina formed in solution. Even so, this method can only be used economically where the bauxite is free from iron or for other reasons unusually costly.

In the following we assume the other method to have been used. As suitable proportion for the above named bauxite, when aiming to produce neutral or basic sulphate of alumina, the writer found 1250 lbs. bauxite and 2800 lbs. sulphuric acid 50° Baumé. This corresponds to 1421 SO_3 or 609 Al_2O_3 (Fe_2O_3) and means with a neutral liquor a practical utilization of 48.7% of the weight of the raw material from a theoretical per cent. of 66 Al_2O_3 (Fe_2O_3).

We have dwelt upon the mixing process, but in the sulphuric-acid method of alum making it is the most important part of the manufacture, and must be watched carefully to insure success.

If it is desired to change the iron present into the ferric state, for the purpose of precipitating it or for some other reason, it must be done in the dissolver while the liquid is yet hot. When the chemical test has shown that the reaction in the mixer is complete—that is, we have obtained a neutral or slightly basic liquor suitable for further treatment—the mass is diluted with weak sulphate of alumina liquor or water as hot as obtainable, until the well-agitated liquid shows a sp. gr. of 1.22 to 1.26 or 26° to 30° Baumé. For neutral solutions the higher strength is admissible, but for basic ores the lower is preferable, as these settle too slowly if 30° Baumé strong, owing to a more viscous condition, due to partly precipitated ferric hydrate.

In special cases it is sometimes advisable to settle the liquor partly in the mixer, but for ordinary work, where the cost of alumina is less than the cost of the equivalent amount of acid, the diluted liquor is at once run off into the settler. In regard to the mixer residuum we will only say here that it varies in composition greatly, sometimes containing much more alumina than in other cases. It is always treated with the acid belonging to the next batch, as already described, and when accumulated so as to cause inconvenience is washed with hot water until no lumps are perceptible and then shoveled out, or better, discharged through a wide pipe in the bottom provided for that purpose. It contains now 25% to 35% alumina upon dry substance, mostly as undecomposed bauxite, and is of no special value (see settling-mud below).

The settlers are round or square lead-lined tanks 2½ to 3 ft. high, provided with agitators in the case of the round tanks. The square ones requiring hand-stirring are not to be recommended. Steam and water-pipes and a sufficient number of discharge openings for clear liquor and residuum are provided for each tank.

When the hot liquor has arrived in the settler, 1 to 2 in. of cold water are run in cautiously on top of the solution in order to keep in the heat and assist the subsidence of the solid matter. This is particularly useful in the case of basic liquors as these do not settle so well and also seem to be acted upon by the oxygen in the air, FeO being converted into Fe_2O_3, some of which may precipi-

tate as basic sulphate of iron or as hydrate. The settling of such liquors takes a longer time than is the case with neutral or acid liquors. These may be left without any cover of water and will be ready in 24 hours, while the basic ones require 72 or more hours, depending upon their specific gravity as mentioned above.

After drawing off the clear solution it is necessary to extract the sulphate of alumina present in the residuum. This is done by thorough washing with hot water under strong agitation repeated as long as a paying strength is obtained. It is better to finish this operation in a filter press, so as to obtain the last wash-waters stronger and less bulky. The cakes are of no value except for brick or cement works, which may be located near the alum factory.

The wash-waters are pumped into lead-lined tanks standing above the mixer, and are used for diluting the contents of the mixers, and if more of them is produced than needed for that purpose, the first and strongest liquor may be evaporated down, settled and used along with the regular article.

The clear sulphate of alumina solution may be treated for removal of the iron according to any one of various patented methods. Of these we will here mention only a few. We may safely ignore all proposals to get rid of the iron by precipitating the alumina until a cheap method is found to precipitate it in a dense condition. Nor do the processes which contemplate the separation of the iron, either as ferric sulphate or ferric chloride, by pressing out the liquid iron salt from the partly solidified sulphate mixture deserve any serious consideration, as they can hardly be made practicable. To remove the iron by washing the bauxite in hydrochloric acid is equally impracticable. In red bauxite, which is very rich in iron, a large percentage is made insoluble in sulphuric acid by means of roasting, but enough is left to be objectionable. The only feasible way of separating the iron seems therefore to be by precipitation. For this purpose the iron is always in the ferric state. To convert the iron into the ferric state we may use either aquafortis, or nitrate of soda, or chloride of lime; the latter should, however, be used with the same precautions as observed when using slacked lime for neutralizing purposes (see above).

Many attempts have been made to use yellow prussiate of potash, but none appear to have proved successful, owing to the bulkiness of the precipitate, the difficulty of separating it from the liquor, the blue color communicated to the filtrate, and the great expense of the reagent itself. Chadwick's and Kynaston's method (U. S. patents 230,106 and 237,816) of adding 3% to 5% of arsenious acid to the bauxite in the dissolver, diluting to 24° Baumé, neutralizing with powdered chalk and allowing the liquid to rest for 14 days, and finally removing the balance of the iron with ferrocyanide of calcium or sulphate of copper or zinc, is objectionable for many reasons. Semper's addition of sulphate of copper (also patented by Chadwick and Kynaston), in slight excess, is ingenious, for it not only takes care of any excess of prussiate, but also helps to cover up any yellow appearance of the finished product; still it was not a success. Semper and Fahlberg turned their attention in another direction, and May 9, 1892, obtained two patents (U. S. patents 257,567–8) for precipitating iron with peroxide of lead. The writer had some experiments made with this reagent, using it in the shape of an orthoplumbate of calcium, which was claimed by the makers to answer just that purpose,

but no satisfactory results were obtained. Very large amounts of the reagent had to be used to get any precipitation. By using a pure peroxide of lead better results are probably arrived at. The inventors claim that 30 minutes stirring in the cold with a sufficient excess is enough for complete separation of the iron.

Another process using a peroxide was that of P. and M. Spence (English patent 3835, Aug. 11, 1882), who added to the hot neutral sulphate solution of 1.25 sp. gr. 6% by weight of sulphates present of hydrated peroxide of manganese in the shape of Weldon mud. After settling the liquid was found nearly free from iron, and produced a practically pure alum. Kynaston (French patent 150,921, Sept. 2, 1882) made use of the same reagent, but used it directly in the mixer, oxidizing and precipitating the iron sulphate as it formed by the action of the acid upon the bauxite. This, however, does not appear feasible in presence of free H_2SO_4. He then diluted the mass to 1.225 sp. gr., and removed the dissolved sulphate of manganese by chloride of lime.

Hydrated peroxide of manganese has proved so satisfactory for separating iron from alumina that it is used even analytically, but then always in a hot, dilute neutral or very slightly acid solution. A few minutes of boiling is sufficient to complete the reaction, provided enough of the reagent is present. This is best prepared by mixing equivalent quantities of sulphate of manganese and permanganate of potash and washing out the sulphate of potash formed along with the peroxide: $MnO, SO_3 + K_2O, Mn_2O_7 + 6\,H_2O = K_2O, SO_3 + 3\,MnO_2, 2\,H_2O + O_2$. The damp manganese peroxide ($MnO_2, 2\,H_2O$) is ready for use as soon as free from sulphate of potash. For manufacturing purposes this method is also patented.

The simplest and cheapest way of getting rid of the iron, a way which ought to interfere with no patents, is to leave the diluted liquor from the mixer strong enough, say 34° to 36° Baumé, to form upon cooling a liberal crop of sulphate of alumina crystals. These are drained and washed with a small amount of cold water in a centrifugal machine, and are then practically free from iron. As the demand for a pure sulphate is not very large, this method can easily be pursued without interfering to any appreciable extent with the quality of the bulk of the ordinary sulphate produced in the works.

It would seem that Newland's process (English patent 5287, Dec. 17, 1880) in which the liquor is concentrated to 36° Baumé, then cooled and settled for 24 hours, and the mother liquor separated by pressing from the crystals formed, is practically the same thing ; what makes his process patentable is presumably substituting pressing for centrifuging or filtering.

For many purposes it is sufficient to simply reduce the iron to the ferrous state. In this condition its harmful action is very much reduced, and it imparts no color to the alum, even when basic. This is a very great advantage to the manufacturer and to the paper-maker (who is the chief consumer), as it enables the former to produce and the latter to use without detriment an alum holding an excess of alumina, and in its sizing action much more efficient than the neutral article holding the same percentage of alumina. Such basic alum is also less injurious in its action upon colors easily affected by sulphuric acid.

For the purpose of converting the iron into the ferrous state many methods have been suggested. Probably the oldest is the use of powdered charcoal with which the clear liquor is boiled during its final evaporation. The properly burnt

article which is used for powder appears unsuitable here, probably because it contains too little hydrocarbon. The brown charcoal which is rich in hydrogen answers best for this purpose. At any rate the action is slow and for that reason and owing to the necessity of settling-out this charcoal it is under all circumstances a very objectionable reagent.

To treat the reduced hot liquor in the mixer with zinc is much better, although it takes a considerable quantity of that metal to accomplish the result aimed at. Some alums contain as much as 8% of sulphate of zinc. As, however, this body is colorless and precipitates the paper-maker's size (rosinate of soda), as well as sulphate of alumina, 140 parts of the former equaling in their effect 100 parts of the latter, this addition to the alum is harmless. Should some of the FeO during the settling or further treatment oxidize itself back to Fe_2O_3 it will be necessary to add some zinc during the final concentration. The use of this metal for reducing the FeO was originally patented by Francis Laur in 1878.

Bihn & Heerlein in 1880 (U. S. patents 233,916 and 234,704) patented the use of sulphites, bisulphites and hyposulphites for this purpose. These reagents do not reduce the last trace, however, whether used in the hot or cold liquor. Skoglund found that the final addition of some stannous chloride to the boiling liquid would reduce the last traces; the bulk of the Fe_2O_3 he reduces with sulphurous acid. This process was carried out thus by the inventor on a large scale at the works of the Martin Kalbfleisch Chemical Company. The clear settled liquor, 26° to 28° Baumé strong, was run into the evaporating tank where the final concentration takes place. To 2500 lbs. of such liquor, 15 to 20 lbs. of bisulphite of soda 36° Baumé, holding 25% of sulphurous acid, were added, the whole well stirred and heated. When the liquor in the tank had obtained a strength of 36° Baumé, 2 lbs. of stannous chloride 54° Baumé, holding 61% $Sn Cl_2+2 H_2O$, were added, having been first diluted with 12 to 15 lbs. of water. The liquor was again stirred and boiled until strong enough. This process introduces no foreign body in the sulphate except the trace of tin oxide. All excess of stannous chloride is easily avoided.

Semper in 1881 (U. S. patent 238,613) proposed the use of oxalic acid or oxalates for the same purpose. The same chemist in 1883 (U. S. patent 280,090) patented the use of zinc sulphite, which he adds as a powder to the molten sulphate of aluminum. The same year (U. S. patent 271,371) he also obtained a patent for the use of sulphites of all kinds for the purpose of reducing iron to the ferrous state, this in spite of the fact that the same thing had already been patented by Bihn & Heerlein in 1881. Previously in 1881 (U. S. patent 245,750) Semper had obtained the right to use sulphurous acid or sulphureted hydrogen, with which he heated the sulphate of aluminum liquor, subdivided into a fine spray.

For the purpose of boiling down the clear settled liquor a round lead-lined tank is generally used. This tank is provided on the bottom with a steam coil for the purpose of heating the liquor. As it is advisable, for the sake of economy, to boil the liquid quite rapidly this coil should be as long as possible, and for a tank 8 ft. in diameter and 3 ft. high we may use in all 300 ft. of ¾-in. heavy lead pipe. It is best to keep the coil 1 in. away from the bottom by means of supporting pieces so as not to obstruct the flow of liquor when discharged and to

prevent too great concentration. The tank has preferably a small fall toward the outlet. The steam pressure used should be 50 to 60 lbs. per sq. in. With a larger tank and more pipe in the coil we may use a smaller steam pressure, as the quality of the product is the same in either case, but the rate of evaporation is of course much slower in the latter. Lower pressure has the advantage of not straining the pipes so severely. The bursting of the pipe, particularly where bent at a sharp angle, is the weak point in any construction of this kind. No matter how heavy the pipe is it seems to swell at such places and finally split, causing loss of time and labor.

The liquid is boiled until the strength corresponding to the percentage of alumina desired in the sulphate is obtained. This is approximately for 14% alumina 52° Baumé, for 15% alumina 55° Baumé, for 16% alumina 58° Baumé, and for 17% alumina 61° Baumé. A stronger sulphate than 17% alumina is seldom desired. During the last stages of the boiling the liquid foams very much, and it is sometimes quite difficult to obtain the correct strength, particularly for the higher percentages of alumina. If the steam is shut off for a few moments, just before taking the sample a good deal of the foam will go down, and by the aid of a little cold water thrown on the surface of the sample to be tested the strength can be obtained with a fair degree of accuracy. When the liquor has been found strong enough the plug is pulled and the contents of the tank is let out on the floor for the purpose of solidifying.

For this floor, which should be as smooth as possible, we may use either a surface composed of large slabs of a fine-grained sandstone with well-trimmed edges, so as to form, when placed together, as narrow joints as possible, or a carefully constructed pavement of acid-proof bricks laid with close joints in plaster of paris. In either case the floor must be surrounded by a 3-in. plank frame lined with lead on the inner side for the purpose of confining the liquor to the floor. It is well to give the floor, which should measure about one square foot for every 4 to 5 lbs. of sulphate solidified, a slight incline outward and to provide a shallow gutter connected with a discharge pipe. The object of this is to give the water, which has to be sprinkled on the floor just before running on the concentrated alum liquor, in order to prevent sticking of the cake to the stone, a chance to run off instead of mixing with and weakening the sulphate of alumina. This watering is particularly important in the case of strictly neutral or slightly basic liquors. We find with them a most decided tendency exhibited by the solid sulphate to stick often so firmly that it is impossible to separate it from the stone without taking a piece of the latter along. In the case of basic liquors such a floor has to be sprinkled with weak sulphuric acid to prevent sticking. As such sulphates are often required, this kind of floor becomes objectionable.

A better solidifying surface is one patented by John Enequist (U. S. patent 520,416), May 29, 1894. Upon a suitable foundation, well seasoned 2-in. pine planks are laid perfectly level. Being of even thickness they form a smooth floor which is edged by the above named 3-in. plank frame. Upon this surface we now screw down by means of 1½-in. brass screws zinc plates ¼ in. thick of the largest dimensions obtainable. In the joints we may put a paste made of plaster of paris. For a batch of 2500 lbs. of 26° to 28° Baumé liquor, yielding

about 1000 lbs. of sulphate of alumina, we require a floor of about 250 sq. ft. Instead of zinc, we may substitute aluminum. The object in using these metals is not only to obviate the sticking of the product, but also to utilize their property of evolving hydrogen with sulphate of alumina for the purpose of producing a very porous condition of the solidifying cake. The hydrogen in rising through the solidifying mass is distributed in very minute bubbles, and these not being able to escape leave the cake in such a spongy condition that the finished article actually floats on water and in warm water, dissolves almost as quickly as thrown in. The porous alum thus produced contains but a trace of zinc and is very much superior to the ordinary grade which is produced by means of bicarbonate of soda sprinkled upon the floor or mixed in with the solidifying mass. The porosity thus obtained is very imperfect and does not fulfill the object of yielding an easily soluble article.

On account of the impossibility of quickly dissolving the solid sulphate, even when broken up in pieces 1½ to 2 in. square, it was found necessary to grind this stuff down to 8 or 10-mesh. This may be done very nicely in a Carlin dry-pan, as mentioned before. In a high speed mill the sulphate becomes hot and bakes very soon. This grinding is obviated by producing at once a suitable porous product such as the one just spoken of.

Almost all kinds of sulphate of alumina, when using the sulphuric acid method, are produced as described by dissolving, settling and evaporating, and yield therefore a product nearly free from insoluble matter. There is, however, an alum-cake used for poor grades of paper produced by running the mixer contents, suitably diluted, at once upon the floor. For analysis of this and other alums, see further on.

MANUFACTURE OF SULPHATE OF ALUMINA FROM BAUXITE BY THE SODA METHOD.

The details of this process were worked out in France, by L. Le Chatelier, who protected his inventions by a great many patents. Some valuable improvements were later added by G. and F. Loewig and K. J. Bayer in Germany. The bauxite used here is generally the red variety, as it contains less silica and holds the iron in such shape that the most of it stops in the insoluble residue, while the white bauxite contains a good deal more silica and gives when melted with soda a greater amount of soluble iron compounds. A bauxite holding 2% of silica is considered satisfactory, and better grades are not easily obtained in quantity. The composition of the French red bauxite, which occurs together with, and is surrounded by, the white or yellow variety is, according to Le Chatelier, as follows :

	First Quality.	Second Quality.	Third Quality.
	Per Cent.	Per Cent.	Per Cent.
Al_2O_3	56.4	52.5	40.5
Fe_2O_3	21.7	29.0	33.8
SiO_2 (+TiO_2)	3.9	2.4	1.7
CaO, CO_2	6.0	0.2	.....
H_2O	12.0	15.9	24.0
	100.0	100.0	100.0

Besides he found traces of chromium, vanadium and tungsten. The same

chemist found that by treatment with hydrochloric acid, there resulted from these minerals respectively the following residues:

Al_2O_3	93.6	95.7	96.0
SiO_2	6.4	4.3	4.0

The average composition of the French red bauxite, as worked in the large factories, may be stated at 60% to 75% alumina (Al_2O_3), 12% to 25% iron sesquioxide (Fe_2O_3), 1 to 3% silica (SiO_2) and 12% water (H_2O). There appear to be but few deposits outside of France fit for working. The mineral used in the modern style of manufacture described below held about 60% alumina, 20% iron sesquioxide, and 15% to 18% water. The mineral is first roasted in a reverberatory furnace; which makes the alumina more soluble and the iron oxide more insoluble, and also assists the subsequent grinding. It is next allowed to cool and then ground as fine as possible and mixed with finely ground soda-ash. It is important that this mixing should be uniform, as the subsequent roasting cannot be properly effected unless the soda-ash is evenly distributed among the batch. The amount of the alkaline carbonate depends somewhat upon the percentage of silica, as that body will absorb soda and form silicate of soda, but allowing for the silica Le Chatelier found in 1859, that if the theoretical amount of soda were taken to each molecule of alumina, part of the soda is left unchanged and the mass may melt. He therefore added burned lime so as to causticise the excess of soda ash. The advantage of this was that the sodium aluminate was not decomposed by the carbonic acid in the air. Finding the alumina much cheaper than the soda, he later preferred to use only 1½ molecule soda or even less upon each molecule alumina. He thus combined all the soda with alumina, and wasted the cheaper material instead of the dearer, at the same time protecting the bed of the furnace against the free alkali. The mixture was heated to white heat without melting it in a reverberatory furnace. The melt was ground up and then lixiviated with hot water, when a sodium aluminate was obtained holding a considerable excess of alumina, which gradually deposited and gave an almost chemically pure hydrate of alumina. From the clear solution the remaining alumina was precipitated by means of carbonic acid and brought on to a vacuum filter where it was washed carefully with hot water to remove as much as possible of the soda drawn down by the alumina. The hydrate of alumina thus produced always contained some soda and also traces of iron in the shape of Na_2O, Fe_2O_3.

Le Chatelier proposed to add some carbon to the soda-bauxite mixture in the furnace in order to avoid the formation of higher oxides of iron by causing this metal to remain behind as insoluble sulphuret. The sulphate always present in soda-ash is reduced by the carbon to Na_2S, and FeS is formed by the action of the sodium sulphide upon the metallic oxide:

$$Fe_2O_3+C=2\,FeO+CO;\ FeO+Na_2S=FeS+Na_2O.$$

He also extracted the iron beforehand by hydrochloric acid from the mineral, although never completely, as proved by his using prussiate of potash to precipitate the iron when preparing sulphate of alumina by the solution in sulphuric acid of the bauxite thus treated.

Le Chatelier next patented a method of mixing powdered bauxite with soda-

ash to a dough and igniting the mass to a very high temperature. By treatment with hot water he now obtained sodium aluminate, while the residue held Fe_2O_3, sodium titanate and sodium-aluminum silicate.

The modern practice differs somewhat from Le Chatelier's, and is as follows: After the finely ground materials have been intimately mixed they are roasted in a furnace identical in every way to the cryolite furnace constructed by Prof. Julius Thomsen of Copenhagen and used extensively for the roasting of cryolite with lime or chalk. The only difference is that in this case, owing to the greater heat required for melting the bauxite and the soda, we use a smaller furnace-bed. This furnace is shown in Figs. 1 and 2, given herewith. *A* and *B* are grates measuring 1 ft. 4 in. by 3 ft. *C* is the furnace-bed (59 sq. ft.), composed of rabbited fireclay tiles 16 in. square by $3\frac{1}{2}$ in. thick. *D D* are fireclay pillars serving as a support for the bed and placed in diagonal rows; they are 6 in. square and 11 in. high, and must be made of the most refractory material obtainable, as they are exposed to white heat. *F* is the fire-bridge, which has running through it longitudinally an air-channel intended for cooling it. The flame travels from *A* under the bed, joins at *E* the products of combustion from the fire-box *B*, and travels then over the fire-bridge *F* and the bed *C* to *G;* from this point it enters the flue *K*, and from there passes through *M* and *N* directly to the chimney. In that case the damper *R* is closed; should, on the contrary, *R* be open and *O* closed the flame from *K* enters the flue *H*, and traveling under the pan *P* enters *J*, and from there, by *L*, *M* and *N*, enters the chimney. *Q* is the arch over the bed, and inclines slightly toward *G* so as to throw the heat at the end of the bed more strongly on the charge. This arch must also be built in the most substantial manner, and should be 9 in. thick. *U* and *V* are the openings through which the coal is fed on the grates *A* and *B*. *T* and *T* are the charging hoppers through which the materials reach the bed, and *S S* are the working doors, also serving to discharge the ready mass. As this furnace is exposed to a very high white heat it follows that it must be very strongly bound in all directions and in general built in the most substantial manner.

For each charge we use 600 lbs. of red bauxite holding 360 lbs. of alumina and $1\frac{1}{4}$ equivalent of 58% soda-ash, or 473 lbs. holding 191 lbs. CO_2, which, together with the 15% to 18% H_2O, are driven off. We can therefore obtain only 1073 (191+100+782) lbs. at the most. The actual weight of the output is generally 760 lbs. The reaction taking place is $Al_2O_3+Na_2O$, $CO_2=Na_2O$, $Al_2O_3+CO_2$; besides, there are formed some sodium silicate and titanate and a small amount of Na_2O, Fe_2O_3. The firing should reach white heat and be continued until no CO_2 is evolved when treating a sample with acid. The operation takes 4 hours and requires 2500 lbs. of the best soft coal. The melt is of a dirty green color, quite porous and friable. It contains in the above case 40% to 42% Al_2O_3 and 33% to 35% Na_2O. An average of six analyses gave (according to Jurisch *Die Fabrikation von Schwefelsaurer Thonerde*, 1894) soluble Al_2O_3, 40.9%; Na_2O, 33.4%; Fe_2O_3, undissolved Al_2O_3, SiO_2, etc., 25.7%.

From this we obtain the proportion of alumina to soda in the usual way:

$$\frac{40.9}{103} : \frac{33.4}{62} = 0.40 : 0.54 \text{ or } 1 \text{ molecule } Al_2O_3 \text{ to } 1.35 \text{ molecules } Na_2O.$$

We have therefore utilized 760 × 0.409 or 311 lbs. out of the possible 360 lbs. alumina, or 86%.

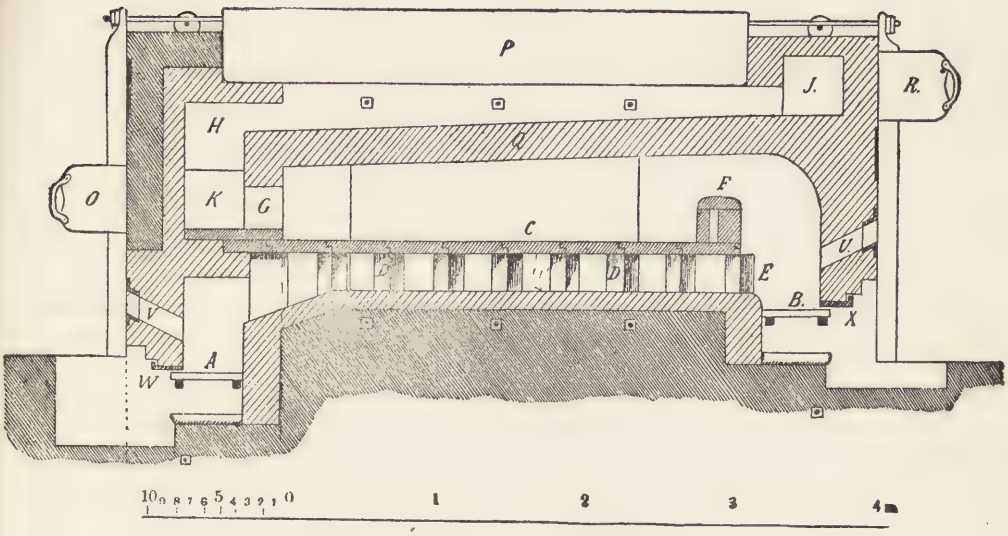


FIG. 1.—LONGITUDINAL SECTION.

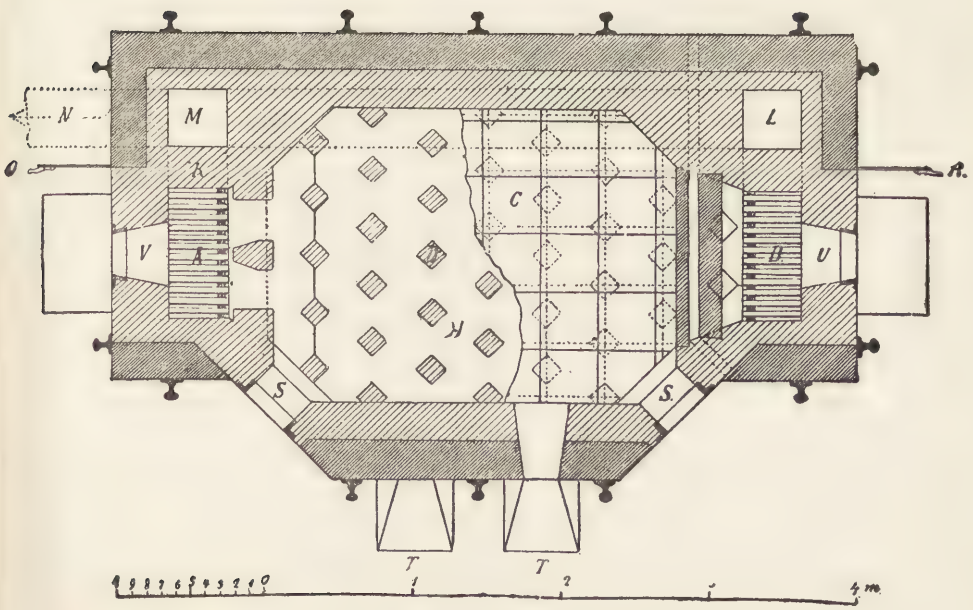


FIG. 2.—PLAN.
THOMSEN'S CRYOLITE FURNACE.

The melt is ground and lixiviated with hot water. As stated above, Le Chatelier obtained a sodium aluminate which gradually deposited pure hydrate of alumina. As the alumina thus separated may be lost among the insoluble matter, this decomposition is avoided in modern practice by performing the lixiviation very rapidly. The ground material is dumped into the dissolver, which is filled with boiling water beforehand, and consists of a round wooden tub provided with a powerful agitator and an open steam-pipe. By these means the solution is effected in 10 minutes at the most. It is preferable to add some caustic soda to the hot water in the dissolver in order to more effectually guard against separation of alumina. Enough is generally added to form in the ready solution 2 Na_2O, Al_2O_3. Sometimes the proportion is only 1.8 Na_2O to 1 Al_2O_3. It is of no advantage to produce the normal 3 Na_2O, Al_2O_3; on the contrary, as much more CO_2 will have to be used in the carbonating process. The proportion between ground melt and hot water should be so adjusted that the ready lye, when discharged, shows 35° to 36° Baumé tested hot.

The hot liquor is immediately run into a filter press and separated from the insoluble matter as quickly as possible. This is important as there is always danger of decomposition as long as the sodium aluminate is in contact with the insoluble matter. This consists of undecomposed bauxite, alumina, iron oxide, sodium carbonate, silicate and titanate and water. The color of the residue varies from dark red to light yellow, according to the proportion of iron contained. The proportion of soda in dry substance averages 5%. This residuum is used to purify illuminating gas from sulphureted hydrogen.

The filtered liquor generally contains some finely suspended ferric oxide. Owing to the rapidity of the filtration this cannot be entirely avoided. Other impurities are the same as held by the soda-ash used, or chiefly sulphate and chloride of sodium. By evaporating this liquor to dryness, we may obtain the solid sodium aluminate, which, if pure, should contain, using the above proportions of soda and alumina (2 Al_2O_3 to 3 Na_2O), 52.5% alumina and 47.5% soda.

The composition of the commercial sodium aluminate varies according to the quality of the soda-ash used. One analysis gave 48% Al_2O_3, 44% Na_2O and 8% NaCl and Na_2O, SO_3; another gave 9% of the impurities. Some grades contain large amounts of insoluble matter in the form of SiO_2 and TiO_2, with a correspondingly low proportion of real sodium aluminate. This article occurs in the trade as a white powder with a tinge of greenish yellow, and is very soluble in both hot and cold water. It absorbs water and carbonic acid on the surface, and is therefore liable to give a clouded solution caused by the separated alumina.

If the clear solution of the aluminate is not evaporated to dryness it is pumped from the filter press to an overhead settling tank, where it is allowed to rest for a few hours in order to separate out the finely suspended ferric oxide which is present to a small extent, as already stated. From there the liquor is run into the carbonator to be charged with carbonic acid. The carbonator is a cylinder 3 ft. in diameter and 10 ft. high, provided at the bottom with a distributing arrangement for the carbonic acid and with an outlet pipe at the top for the unconsumed gas. Besides, there is an inlet pipe for the liquor at the top and a discharge opening at the bottom. The latter opening must be large enough to

allow the mixture of liquor and precipitated alumina to run readily out of the cylinder into the filter press.

The carbonator filled with the liquor is heated by means of an open steam-pipe to a temperature of 50° to 90° C. As soon as the liquor has reached the temperature of 50° C., the carbonic acid is pumped into it through the distributor. No successful method of utilizing the carbonic acid evolved from the furnace decomposition of the soda-ash with the bauxite exists, but it is necessary to obtain it either from limestone or from the burning of coke. In the case of limestone, we may obtain the gas either by the dry process through burning, or by the wet process by means of an acid. From whatever source obtained, the gas should be as strong as possible and ought not to contain less than 16% of carbonic acid; it should also be as dry and as free from organic matter as possible and has therefore to be suitably washed. The reaction taking place during the carbonation is as follows :

$$3\ Na_2O,\ 2\ Al_2O_3 + 6\ H_2O + 3\ CO_2 = 3\ (Na_2O,\ CO_2) + 2\ (Al_2O_3,\ 3\ H_2O).$$

From which we see that 186 parts soda require 142 parts carbonic acid. In practice, however, we use about 200 parts carbonic acid, a portion of which is consumed in the formation of sodium bicarbonate.

A. Ditte has found that only in the presence of small amounts of sodium carbonate does the alumina precipitate as pure hydrate in the crystalline form; when more of the carbonate ($NaO,\ CO_2$) is present the body $2\ Al_2O_3,\ 3\ Na_2O,\ 5\ CO_2$ is formed. A. Benzon, the Danish manufacturer of soda from cryolite, corroborated this observation. He found that carbonic acid did not precipitate the hydrate from the sodium-aluminate lyes, but instead the substance $7\ Al_2O_3$, $3\ (Na_2O,\ CO_2)$, $30\ H_2O$, holding 45% Al_2O_3, 20% Na_2O, CO_2 and 35% H_2O. By long-continued washing with hot water the soda is extracted from this body.

In order to obtain the hydrate in a heavy and crystalline condition it is necessary that the solution of the aluminate should be no less than 35° Baumé strong, tested hot as stated above. Should the strength go below 35° the alumina will precipitate as gelatinous hydrate, which would simply mean the complete choking of the apparatus.

When the chemical test shows that the carbonation is complete the contents of the cylinder are at once run into the filter press. After the liquor is run off as completely as possible the hydrate of alumina is washed in the filter press with boiling hot water in order to extract as completely as possible the sodium carbonate adhering. It is never possible to completely remove the soda by this means. There will always remain at least 2% counted upon dry hydrate. To remove this impurity, which as a rule does no harm, it is necessary to either wash with dilute hydrochloric acid or to ignite the dry hydrate strongly enough to cause the conversion of all the soda into sodium aluminate. It is, however, generally unnecessary to eliminate the soda, as its presence is of no consequence. A more serious impurity is the oxide of iron, which is likely to occur to the extent of 0.02% to 0.03%. The presence of this is owing to the formation during the melting process of $Na_2O,\ Fe_2O_3$ which should be, but has not been, completely decomposed in the lixiviating process. There is no way of removing this amount of iron unless, for the purpose of extracting the soda, we decide to wash

the hydrate with hydrochloric acid. This should at the same time remove the ferric oxide. We have above mentioned Le Chatelier's attempt to prevent the formation of this compound (Na_2O, Fe_2O_3) by adding carbon in his furnace mixture and also his process of extracting the iron from the bauxite itself. Neither of these methods seems to be employed on a large scale.

The filtrate from the filter press is collected together with enough of the wash-water to bring the strength down to 30° Baumé. The weaker wash-waters are collected separately and evaporated down. The 30° Baumé liquor is run into crystallizing tanks where the carbonate of soda deposits in the shape of sal soda. As the liquor generally contains some bicarbonate an equivalent amount of caustic soda has to be added to neutralize that body. In order to obtain a nice crystal enough sulphate of soda is also added to leave in the finished crystals 2% to 4% of sulphate.

To finally prepare the pure sulphate of alumina from the hydrate of alumina, we use the same apparatus as previously described for the manufacture of the ordinary quality of sulphate, that is, either a lead-lined tank provided with a long coil of heavy lead pipe on its bottom, or else a steam-jacketed copper vessel. In the latter case the discharge pipe is constructed somewhat differently; it is made of heavy copper pipe and the joint made good on the outside by means of a lock-nut or a regular packing box. The alumina is shoveled into the hot acid in the proportion of 100 lbs. hydrate, holding 62% alumina, to 191 lbs. of sulphuric acid 66° Baumé. This corresponds to the formula $Al_2O_3+3\ (H_2O,\ SO_3)=Al_2O_3,\ 3\ SO_3+3\ H_2O$, or to 157 parts pure hydrate to $3\times98\times\frac{100}{93.5}$ or 314.4 commercial oil of vitrol (American standard or 93.5% $H_2O,\ SO_3$); thus exactly 1 part pure hydrate of alumina is required for every 2 parts oil of vitriol. If the acid cannot be conveniently weighed or accurately measured out, the hydrate is added as long as it dissolves, or until a neutral reaction is obtained, or the desired acidity, if acid sulphate like the German article is desired.

A basic sulphate is not obtained even when boiling with excess of the hydrate, as the latter does not dissolve in the once neutral solution, but reacts on the neutral sulphate according to the following formula:

$$2\ (Al_2O_3,\ 3\ H_2O)+Al_2O_3,\ 3\ SO_3+4\ H_2O=3\ Al_2O_3,\ 2\ SO_3+9\ H_2O+H_2O,\ SO_3.$$

The substance $3\ Al_2O_3,\ 2\ SO_3+9\ H_2O$ is insoluble in the liquid and remains partly suspended. The sulphate produced therefore gives a cloudy solution. Boiling with an excess of the hydrate instead of making a basic liquor causes a liberation of acid, which if no more hydrate were present to neutralize the same, would increase and not lessen the acid character of the liquid. This accounts in many cases for the acidity of the pure sulphate of alumina of the trade, particularly when accompanied by insoluble matter. This free acid will sometimes run as high as 3% $H_2O,\ SO_3$.

Free acid and insoluble matter can, of course, also be present at the same time, in case the alumina, owing to insufficient heating and agitation, has not had time to dissolve completely in the acid.

It should be borne in mind that the commercial sulphuric acid, particularly if made from pyrites, may contain considerable amounts of iron, and may thus spoil a hydrate of alumina, in itself practically free from iron. The acid should

therefore always be tested for this impurity and brimstone acid used wherever possible. The importance of this is easily understood when we remember that nearly two parts of strong sulphuric acid are used to one of hydrate, thus in one case when using a hydrate holding only 0.013 Fe_2O_3 we obtained a sulphate holding 0.04% Fe_2O_3.

Other Proposed Methods of Obtaining Alumina from Bauxite by Means of Soda.—In 1877 G. and F. Loewig received a German patent for a process in which sodium aluminate was decomposed by lime and thus a solution of caustic soda and a precipitate of calcium aluminate were obtained. After separating and washing the precipitate, it was divided into two equal parts; one half was dissolved in hydrochloric acid and the solution from it mixed with the other half of the precipitate. This gave a solution of chloride of calcium and a precipitate of pure hydrate of alumina. The reactions are expressed by the following formulas:

$$2\ (3\ Na_2O,\ Al_2O_3)+6\ CaO=2\ (3\ CaO,\ Al_2O_3)+6\ Na_2O.$$
$$3\ CaO,\ Al_2O_3+12\ HCl=3\ CaCl_2+Al_2Cl_6+6\ H_2O.$$
$$3\ CaO,\ Al_2O_3+Al_2Cl_6=3\ CaCl_2+2\ Al_2O_3.$$

In a later patent, Loewig proposed to ignite the bauxite with its equivalent of soda, so that the two bodies, Na_2O, Al_2O_3 and Na_2O, Fe_2O_3, were obtained. The latter compound is, as we have previously stated, decomposed in the dissolvers into caustic soda and ferric oxide. He also found that by igniting this ferric oxide with soda-ash the same compound, Na_2O, Fe_2O_3, was again formed, and this led him to suggest what has since been attempted by eminent chemists in England—to employ these two reactions for the manufacture of caustic soda.

K. J. Bayer, another German chemist, in 1887 (German patent 43,977) recommended to use with each molecule of sesquioxides one or at most 1.2 molecules of soda. The sodium aluminate solution obtained, which held with each molecule Al_2O_3 1.8 molecules Na_2O, he found would decompose itself, slowly if left at rest, quickly if dry hydrate of alumina was added to it with constant agitation. This separation was well known long before, but had always been considered a difficulty to contend with and had never before been turned to practical use. The hydrate of alumina separates in the hard crystalline form even at an ordinary temperature and continues to do so until the solution contains with each molecule alumina 6 molecules soda. This lye when evaporated acts like caustic soda and may be used for decomposing another quantity of bauxite. This process, as well as Loewig's, does away entirely with the carbonating process, but Bayer's has the advantage that both the silicic and phosphoric acids stay in the solution, and the alumina obtained is therefore exceptionally pure. How the separation proceeds is shown in the following table, where the amount of alumina precipitated after a certain number of hours is indicated in grams per liter, both (A) for liquor at rest, and (B) when agitated with powdered dried hydrate of alumina.

	Fresh Liquor.	After 48 Hours.	After 66 Hours.	After 110 Hours.	After 130 Hours.	Sometimes the separation in B goes much quicker than in this sample.
A.....	63.49	56.26	45.60	.....	42.60	
B.....	63.49	35.78	29.44	21.80	17.71	

After four days the separation is considered complete for practical purposes.

Instead of igniting bauxite with dry soda ash it may be boiled in a finely powdered condition with caustic soda. Several patents have been taken out by Bayer and others for that process. Bayer found that the above-named lye containing Al_2O_3 , 6 Na_2O could be used as well as caustic soda. For this purpose he evaporated the lye to 40° to 44° Baumé and treated the bauxite under constant agitation at a pressure of from 3 to 4 atmospheres with this lye during 1½ to 2 hours. If the bauxite is sufficiently fine, and does not contain too much silica, almost all of the alumina is extracted, with the exception of what remains as Na_2O, Al_2O_3, $SiO_2 + 9\,H_2O$, which is not affected by caustic soda.

Manufacture of Sulphate of Alumina from Alunite.—This is described under the head of alum.

Manufacture of Sulphate of Alumina from Cryolite.—This mineral is used for the manufacture of alum, as stated in THE MINERAL INDUSTRY, Vol. I., in only three factories—two in Denmark and at the Pennsylvania Salt Manufactuing Company's works at Natrona, Penn. In this industry the soda is the chief product and the hydrate of alumina a by-product. We shall therefore enter into no extensive description of it.

The chemical formula of this mineral is 6 NaF, Al_2F_6, corresponding to 12.98% Al, 32.81% Na and 54.21% F. The mineral contains 85% to 90% of the pure double fluoride, 5% silica and 5% iron carbonate, mixed with a small amount of galena, blende, etc. Three methods for working cryolite are used.

(*a*) Decomposition by Lime or Calcium Carbonate by the Dry Process: The mineral is heated in the shape of a fine powder with either ground lime or chalk. This is done in Professor Thomsen's cryolite furnace already described in this article. When used for this purpose the furnace has a bed measuring 13 ft. by 8 ft. instead of 9 ft. by 6 ft. 6 in., all other dimensions remaining the same. The object of the two fireplaces is to obtain an equally high heat all over the bed. When using an ordinary reverberatory furnace, as was done in the factory at Harburg, in Germany, now shut down, it was found that the charge fluxed at the fire-bridge and that undecomposed material remained at the end of the bed. The fluxed parts were found very difficult to leach, and had to be broken up and ground before satisfactory results could be obtained. Such a furnace therefore proved unsuitable, while the Thomsen furnace has been found entirely satisfactory. The materials must be very intimately mixed in order to obtain a good yield. This has to be done in specially constructed mills.

At the Natrona works (according to a pamphlet issued by the Pennsylvania Salt Manufacturing Company, in connection with its exhibit at the Chicago Exposition in 1893) the mineral is crushed, ground and bolted as fine as flour. It is then mixed with 1½ times its own weight of dried limestone and again ground, then charged into the furnace and roasted at a red heat during two hours. The reaction starts below red heat but is only complete at that temperature. It is expressed by the following formulas:

$$6\ NaF,\ Al_2F_6 + 6\ CaO = 6\ CaF_2 + 3\ Na_2O,\ Al_2O_3;$$

or if using chalk: $6\ NaF,\ Al_2F_6 + 6\ (CaO,\ CO_2) = 6\ CaF_2 + 3\ Na_2O,\ Al_2O_3 + 6\ CO_2$.

At the Copenhagen works 12 charges of 500 kilos mixture—208 of cryolite

and 292 of limestone—are worked every 24 hours with a consumption of 15% of soft coal. The waste heat from the furnace is used for drying the limestone and evaporating the soda lyes.

At Natrona the furnace product is lixiviated in the well-known Shank's continuous apparatus as used in the Leblanc process for leaching the black-ash balls. This separates the aluminate from the insoluble calcium fluoride. The solution, which should stand 36° to 40° Baumé, contains caustic soda and carbonate of soda besides the sodium aluminate. This lye is run off into storage tanks and drawn as needed into the carbonators. The latter are a series of iron cylinders provided with agitators as described under the soda-bauxite process. The carbonic acid is obtained from limekilns, is washed in coke towers and then pumped into the lye through a suitable distributing arrangement. The alumina precipitates in a dense form. It is first obtained as a compound with 20% carbonate of soda, which can only be removed, and then not entirely, by very careful washing with hot water. This alumina is partly converted into sulphate of alumina, "Natrona porous alum," and part of it sold to the Pittsburg Reduction Company and others as a raw material for the manufacture of metallic aluminum.

The carbonate of soda solution is concentrated to 36° Baumé and either made into sal-soda or bicarbonate of soda. Part of the lye is causticised with the burnt lime obtained from the limekiln.

The calcium fluoride, which contains considerable carbonate of lime and the most of the impurities of the cryolite, chiefly iron and silicic acid, is used in smelting certain gold ores and also as a flux in the production of cheaper grades of opaque glass. It is not suitable for fine glass on account of its iron, nor for the production of hydrochloric acid on account of the lime and the silicic acid contained in it.

The yield obtained from the cryolite corresponds, with careful work, to 96% of the theoretical, so that from 100 lbs. mineral 90% pure we obtain 33 lbs. hydrate of alumina, or 300 lbs. potash alum and 72½ lbs. calcined soda-ash containing 90% carbonate of soda. This corresponds in sal-soda to 197 lbs. or to 53 lbs. caustic soda holding 72% Na_2O.

(*b*) Decomposition with Lime by the Wet Process (Sauerwein's Method): Finely ground cryolite and slacked lime, as free from iron as possible, are boiled together in a lead-lined vessel, when the reaction, above described, takes place, the advantage being that here we obtain the sodium aluminate in solution at once. The solution is decanted, the residue washed, etc., as usual in all such operations, and the hot solution treated under constant agitation with cryolite in excess ground as fine as possible, when the following reaction takes place:

$$3\,Na_2O,\,Al_2O_3 + 6\,NaF,\,Al_2F_6 = 12\,NaF + 2\,Al_2O_3.$$

There is danger of the precipitated alumina enclosing particles of undecomposed cryolite; constant agitation and a fine state of subdivision of the mineral are therefore absolutely necessary. The end of the reaction is marked by the disappearance of caustic soda in a filtered sample. At that point the liquor is settled and the clear solution drawn off, the alumina washed and dissolved in sulphuric acid. The NaF solution is now heated with lime and thus caustic soda and calcium fluoride produced. The former is concentrated and made marketable in the usual way.

(*c*) Decomposition by Means of Sulphuric Acid: This third method is to treat the ground mineral with chamber-acid, as was done formerly in Weber's factory at Copenhagen, where the sulphate of soda obtained was afterward converted into soda-ash by means of the Leblanc process. The reaction showing the decomposition of the cryolite is:

$$6\ NaF,\ Al_2F_6 + 6\ (H_2O,\ SO_3) = 3\ (Na_2O,\ SO_3) + Al_2O_3,\ 3\ SO_3 + 12\ HF.$$

The sulphate of soda was separated by crystallization after suitable concentration, and the sulphate of alumina used for alum manufacture. The hydrofluoric acid was condensed or converted into solid fluorides. The process was not a success and was soon abandoned. Several objections were urged against it, but none appear to be very sound. The loss of sulphuric acid, for instance, is no greater here than in the Leblanc process. The labor was said to be greater in this process than in the two described above, which is hard to understand. The difficulty of separating the two sulphates and of effecting a complete decomposition of the mineral, and thus obtaining a full yield of hydrofluoric acid and the other products, probably had more to do with the failure of the process than the other objections urged.

Below we give the analysis of a number of different kinds of sulphate of alumina, together with the theoretical composition of the two hydrated salts most nearly approached by the commercial articles.

	1	2	3	4	5	6	7	8	9	10	11	12	13
Alumina	14.65	15.44	14.00	14.35	14.55	15.03	14.40	15.24	12.51	13.54	15.54	14.50	17.4
Basic alumina	.....	.....	.....	.....	.....	.....	.....	0.76	0.84	0.21	0.96	.....	....
Sulphuric acid	34.14	35.98	34.41	35.30	35.73	36.86	33.95	35.89	30.65	31.97	36.54	33.70	40.6
Free acid	.....	.....	0.24	0.50	0.50	0.18	2.06	.....	.....	.....	.....	.....	....
Sulphate of soda	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.60	....
Iron oxide	.....	.....	1.18	1.20	1.20	1.22	0.23	.....	.....	0.06	0.01	0.02	....
Iron oxide as FeO	.....	.....	.....	.....	.....	.....	.....	0.22	0.96	0.20	0.17	.....	....
Insoluble	.....	.....	0.04	0.04	0.04	0.04	3.28	0.92	1.48	8.28	0.11	0.50	....
Sulphate of zinc	.....	.....	.....	.....	.....	.....	.....	.....	8.61	.....	.....	.....	....
Water	51.21	48.58	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	42.0

No. 1 is Al_2O_3, 3 SO_3+20 H_2O; No. 2 is Al_2O_3, 3 SO_3 + 18 H_2O; Nos. 3 to 6 represent an ordinary grade used for filtering purposes made by the writer and run off respectively at 54°, 55°, 56° and 58° Baumé; No. 7 is an impure alum cake made directly by dissolving bauxite in sulphuric acid and solidifying the mass without previous settling; No. 8 is a superior grade used for sizing fine qualities of paper, also made by the writer. The iron in it was reduced by SO_2 and $SnCl_2$. Nos. 7 and 8 are both made from bauxite from the Warwhoop bank, Alabama, containing 1% or less of iron oxide. No. 9 is another grade much fancied by the paper-makers and selling under the name of "Pearl" alum, made by a Philadelphia manufacturer; No. 10 is another article made by the same firm also in favor among the paper mills; No. 11 is a New York make of high quality also designed for paper-makers; Nos. 3 to 11 are all made by the American or the sulphuric acid method; No. 12 is an average sample of the output of a German factory using the soda method (Jurisch). The percentage of iron oxide runs in this make between 0.06% and 0.017%. No. 13 represents porous alum made from cryolite by the Pennsylvania Salt Manufacturing Company; it holds some of the alumina as insoluble basic sulphate and also variable amounts of sulphate of soda.

Impurities.—Among the impurities in alum, iron is the most objectionable. If the sulphate is perfectly neutral or slightly basic, even 0.05% iron oxide will color the product slightly, and with 0.15% present it becomes quite yellow; but if the iron is present as ferrous oxide no coloration is visible before the proportion of iron has reached 0.6% to 0.7%. The reason is that the ferrous sulphate is only faintly colored. The insoluble matter which is also objectionable, but in a much less degree, may be silica, alumina, undecomposed bauxite or basic sulphate of alumina, depending upon the mode of manufacture. Other impurities may be potash, lime, magnesia and TiO_2. Small amounts of chlorine, nitric acid, copper, lead and arsenic may also be present. This does not include the impurities mentioned in the above table of analysis.

Cost of Manufacture.—This may be stated as follows:

1. By the American method or decomposition of white bauxite with sulphuric acid:

Bauxite, 3750 lbs. at $8 per 2240 lbs	$13.36
Chamber acid 50° Baumé, 9500 lbs. at 35c. per cwt	33.25
Water (provision made for return of condensed water), 5560 gals. at 2c. per 100 gals	1.11
Coal, 13,600 lbs. cheap steam coal at $2.24 per long ton	13.60
Labor, 7 men at $1.50	10.50
Superintendence	7.00
Repairs	4.50
Barrels (non-returnable) 32 at 24c	7.68
General expenses	6.00
Total	$97.00

A product of 11,250 lbs. sulphate of alumina, holding 15% to 16% alumina, at a cost of $97. Thus making a yield of 300% upon the bauxite used. Cost per 100 lbs. in factory ready for shipment is therefore 86.2c. This cost may be further lessened by making the sulphate porous, enabling the manufacturer to ship in returnable bags beside saving the cost of grinding.

2. By the German method or decomposition of red bauxite by melting with soda-ash (from the *Chemische Fabrik Goldschmieden*, Jurisch, p. 87). The prices are the German ones expressed in dollars:

310 lbs. red bauxite at $12.67 per long ton	$1.75
410 lbs. oil of vitriol at $6.10 per 2000 lbs	1.25
810 lbs. coal at $3.25 per long ton	1.17
35 lbs. soda-ash (53 per cent. or 90 per cent. Na_2CO_3) at $17.54 per 2000 lbs.	0.31
Steam (not included in coal above)	0.78
Repairs	0.22
Wages	1.62
Packages (not mentioned in the original), American price	0.75
General expenses (omitted in the original)	0.75
Total	$8.60

A product of 1000 lbs. 48% sulphate of alumina for $8.60, or a cost per 100 lbs. in factory ready for shipment of 86c.

The price of bauxite is probably too high, the prices of oil of vitriol 66° and soda-ash are the factory's own manufacturing costs. The soda here represents only the difference between the amount used and amount produced afterward in shape of sal-soda. The sulphate produced held 14.37% alumina and represents therefore a utilization of 46.4% alumina from the bauxite used.

MANUFACTURE OF CRYSTAL ALUM.

Composition and Properties of Alum.—We may express the alum molecule by the general formula: R_2O, SO_3 + R_2O_3, 3 SO_3 + 24 H_2O, where R_2O represents a mono-atomic alkali metal, potassium, sodium, cæsium, rubidium or thallium, or the radical ammonium and R_2O_3, a sesquioxide of either aluminum, iron, chromium, manganese, indium or gallium. Omitting the rare metals, rubidium, cæsium, thallium, indium and gallium, we have thus no less than twelve separate kinds of alum, as each one of the four sesquioxides, Al_2O_3, Fe_2O_3, Cr_2O_3 and Mn_2O_3, gives three different alums, a potash alum, an ammonia alum and a soda alum. All these crystallize in the same form, regular octohedrons, and all contain 24 parts water. Only four of these are of sufficient practical importance to require mention here. These are the three alums containing alumina and the chromium-potassium alum. The 24 molecules of water are one of the chief characteristics of crystal alum and other double sulphates, as for instance K_2O, SO_3 + FeO, SO_3 + 6 H_2O, not holding 24 H_2O, are not counted among the alums.

Potash Alum: K_2O, SO_3 + Al_2O_3, 3 SO_3 + 24 H_2O.

Composition: 18.33% K_2O, SO_3 = 9.91% K_2O + 8.42 SO_3.
36.15% Al_2O_3, 3 SO_3 = 10.84% Al_2O_3 + 25.31 SO_3.
and 45.52% H_2O = 45.52% H_2O.

or 100.00% potash alum = 9.91 K_2O + 10.84 Al_2O_3 + 33.73 SO_3 + 45.52 H_2O.

The properties of potash alum are a sweet astringent taste and acid reaction; it dissolves iron, zinc and aluminum. Heated with chloride of sodium or potassium it generates hydrochloric acid and basic alum is formed. In concentrated solution, alum, when boiled with potassium chloride, gives rise to the same reaction, which does not take place, however, so readily in the case of sodium chloride, and not at all in the case of ammonium chloride. The concentrated solution heated with common salt and nitrate of soda generates chlorine and is thus able to dissolve gold.

Alum does not effloresce nor does it lose any water below 30° C. At 42° C. it loses 11 molecules water; at 61° C. when heated in a closed vessel over sulphuric acid it loses 18 molecules water; at 92° C. it melts, and at 100° C. it becomes slowly anhydrous, losing no sulphuric acid and remaining as soluble in water as the crystals themselves. This makes the so-called burnt alum, which is, however, generally produced at a higher temperature and then is less soluble in water. If properly burnt it is, however, always soluble in a large amount of water without residue. If heated to bright red heat, alum, like sulphate of alumina, gives off sulphuric and sulphurous acids and oxygen and forms potash sulphate and alumina (holding some sulphuric acid); at white heat potassium aluminate is formed.

Insoluble anhydrous alum may be produced from crystal alum and concentrated sulphuric acid by heating them together. Water has very little effect on this article, and it has to rest for 8 to 10 days under water in order to be converted into ordinary alum.

The aqueous solution of potash alum, if sufficiently dilute, precipitates upon

heating, with separation of basic alum. This gelatinous precipitate is capable of carrying down coloring matters and most organic impurities. This gives the alum a very important application in clarifying and purifying water as well as sewage.

Basic or "neutral" alum, so called, is alum to which as much alkaline carbonate as possible has been added without producing a precipitate, its composition is K_2O, $SO_3 + Al_2O_3$, 3 $SO_3 + Al_2O_3$, 3 H_2O. If this is heated, we get insoluble alum or artificial alunite, the composition of which is K_2O, $SO_3 + Al_2O_3$, 3 $SO_3 + 2\ Al_2O_3$, 3 H_2O. By heating either of these compounds, they are decomposed with formation of alumina and ordinary alum, which latter may be extracted with water.

Manufacture of Potash Alum from Bauxite.—The ground bauxite is dissolved in sulphuric acid in the same manner as described under sulphate of alumina, with the difference that we here desire an acid instead of a neutral solution, and therefore use a larger percentage of acid upon the bauxite. About 1250 lbs. bauxite and 3300 lbs. sulphuric acid 50° Baumé will be found a suitable proportion when using the same bauxite as mentioned above under sulphate of alumina. The excess of free acid in the ready mixture when diluted ought not to exceed 1½% of H_2O, SO_3. The "mix" is diluted with pure water or weak liquors to about 29° to 30° Baumé. No greater dilution is necessary in this case, as being an acid liquor it will settle more readily than a neutral. In case both sulphate of alumina and crystal alum are made in the same factory, it is well to keep a separate storage tank for each kind of weak liquors, as otherwise we might waste considerable potash. In general, it may be said that it is necessary to exercise great care in regard to the weak liquors in this particular, as impurities will injure the sulphate of alumina much quicker than the crystal alum. The diluted liquor generally settles over night, and is then drawn by means of siphons working either by gravity or by steam into the evaporating tank, which is preferably a round, strongly built wooden tank lined with lead, which should not be less than 8 lbs. to the square foot for the bottom, and 6 lbs. for the sides, in fact 8 and 10 lb. lead respectively would be better. A tank, 15 ft. in diameter at the bottom and 5 ft. high, will be large enough to receive the liquors from 7500 lbs. of bauxite, or 6 charges of 1250 lbs. each. This tank is provided on the bottom with at least 350 to 400 ft. of heavy 1-in. lead pipe of the best make obtainable.

Owing to the acidity of the solution it is important that the metal in this pipe should be as free from dross and other impurities as possible, as these are quickly dissolved out, thus honeycombing and greatly weakening the pipe. When these pipes burst, as often happens when in use for some time, the only way to repair them is to pull the pipe out of the solution after locating the leak. For that reason it is best to have no more than 50 ft., or at the most 65 ft. served by one valve; we use for such a tank six supply valves and connect the pipes at the exhaust end by means of iron flanges to a manifold from which we may carry away the condensed water, to be either returned to the boiler or delivered in a hot water tank on the roof for the purpose of diluting the contents of the mixers. By this arrangement it is possible to easily locate the leaky pipe and when found to disconnect the same at both ends, using a blank flange to close the exposed

opening on the manifold. The pipe can now be pulled up until the leak is found and again let down in the liquor and connected when repaired.

The solution is now boiled until it has obtained a strength of 38° Baumé, measured hot, when it holds about 30% by weight of sulphate of alumina. The amount of free acid should now be at least 2 to 2½% (H_2O, SO_3) by weight upon the 38° liquor. The solution is now ready to receive the potash required for the alum formation. This is generally the sulphate or a mixture of it with muriate of potash.

The average composition of the 90% sulphate of potash, which is the basis upon which this salt is sold, is given below in (1). The average composition of the 96% sulphate, which is a higher commercial grade is given in (2), and the average composition of the 90% muriate of potash in (3).

	1	2	3
	Per Cent.	Per Cent.	Per Cent.
Potassium sulphate (K_2O, SO_3)..	90.6	97.2	.....
Potassium chloride (KCl).....	1.6	0.3	91.7
Magnesium sulphate (MgO, SO_3).	2.7	0.7	0.2
Magnesium chloride ($MgCl_2$).....	1.0	0.4	0.2
Sodium chloride (NaCl).....	1.2	0.2	7.1
Zinc sulphate (CaO, SO_3).....	0.4	0.3	.....
Insoluble	0.3	0.2	0.2
Water (H_2O).....	2.2	0.7	0.6
	100.0	100.0	100.0
Total potash.....	49.9	52.7	57.9
Total chlorine.....	2.24 (Equal to 4.70 KCl.)	0.56 (Equal to 1.18 KCl.)	

Even if only the sulphate is used, say the 90%, we have thus still chlorides present equivalent to 4.70% potassium chloride.

If enough iron salts are present to decompose all the potassium chloride into K_2O, SO_3, no free acid should be needed, but it is advisable to always have free acid present to avoid the formation of basic sulphate of alumina and to retard the oxidation of FeO to Fe_2O_3. Should not as much iron salts be present as is required for converting all the potassium and other chlorides into sulphates, it is necessary to have free acid in the solution to convert the remaining chlorides into sulphates. In brief, there should be as much acid present either as free acid or combined with iron as is required to change all the chlorides into sulphates, if not, the undecomposed potassium chloride will react with the sulphate of alumina and form chloride of alumina, which will be lost. The reactions taking place are

$$FeO,\ SO_3 + 2\ KCl = FeCl_2 + K_2O,\ SO_3.$$
$$Fe_2O_3,\ 3\ SO_3 + 6\ KCl = Fe_2Cl_6 + 3\ (K_2O,\ SO_3)$$
$$H_2O,\ SO_3 + 2\ KCl = 2\ HCl + K_2O,\ SO_3.$$
$$Al_2O_3,\ 3\ SO_3 + 6\ KCl = Al_2Cl_6 + 3\ (K_2O,\ SO_3).$$

Potash should not be added in excess, as K_2O, SO_3; FeO, $SO_3 + 6\ H_2O$ will form in that case. If the iron is present as ferric sulphate, there is danger of it forming iron alum with some of the potassium sulphate, and thus making the potash alum very impure. Therefore it is better to have the iron present in the ferrous state, if there is not too much of it. It is preferable to have the iron in the

shape of chlorides if the alum from the first crystallization has to be redissolved again. To accomplish this we must use enough potash in the shape of chloride to be equivalent to the acid existing in the free state and in combination with iron. This represents the maximum of potassium chloride allowable, and means a considerable saving, as muriate of potash is not only cheaper than the sulphate but also more effective (the relative cost of potash in the shape of chloride and sulphate is as 6 to 7). There is now no danger of ferric alum forming, nor can the FeO, SO_3, K_2O, $SO_3 + 6\ H_2O$ form, should potash have been added in excess. If the first crystals are intended for the market, however, the iron is best left as ferrous sulphate, as this salt has very little color, while the ferric salts impart a strong yellow color remaining even after washing the crystals.

To find the absolute amount of potash required, a test is made each time. As potash alum is insoluble in a solution holding anything over 6% of sulphate of alumina, we may use for this test a solution of sulphate of potash sufficiently diluted not to deposit crystals itself. A 5% solution will answer. This is gradually added to a sample of the liquor until a further addition ceases to cause any fresh formation of crystals even upon prolonged standing in a cold place. As this method is slow, it is generally preferred to make the test in another way, viz., to use two solutions, one of potassium sulphate, the other of aluminum sulphate, and to add potassium sulphate until the point is reached where either solution will produce in the filtered sample an equally large precipitate. Best of all, if time admits it, is to add to a sample of the liquor an excess of potassium sulphate and allow the sample to stand over night, then to collect and weigh the alum crystals formed and from the weight calculate the potash required. Instead of sulphate of potash, the ammonium sulphate may be used. It has the advantage of being more soluble.

The HCl liberated when using sulphuric acid in excess over that required to form potash sulphate with all the potash, increases the wear and tear upon the lead but helps also to prevent the formation of basic salts during the concentration. Part of it is boiled away but the most of it is found in the mother liquors again.

Using 3300 lbs. chamber acid, equivalent to 1674 lbs. sulphuric acid, to 1250 lbs. of bauxite holding 66% alumina, 3.2% ferric oxide and extracting 53½% (which can be done readily), we obtain from 6 mixes, or 7500 lbs. bauxite, 4008 lbs. alumina and ferric oxide ; 208 lbs. of these we may assume are ferric oxide and 3800 lbs. therefore alumina, which will require 6530 lbs. pure potassium sulphate, or a corresponding quantity of the commercial article. This is shoveled in dry with agitation, the liquor is boiled until it reaches 48° to 50° Baumé, measured hot ; it is then covered with some cold water and allowed to settle for a few hours. It is then drawn off into the crystallizers or "coolers." These are square tanks so proportioned as to hold the liquors from six mixers, or the contents of the boiling tank when concentrated, measuring in the present case 12 ft. by 12 ft. by 3 ft. 8 in. Before running in the hot liquor, strips of lead or pieces of lead pipe suspended from iron pipes, or other supports, are hung in the coolers so as to dip into the liquor 24 to 30 in. when the cooler is filled. About 50 of these pieces or "hangers" are used, and their object is to allow to the crystals forming, a surface upon which to deposit and thus to relieve the sides

and bottom somewhat, as these would otherwise be too heavy and require too much labor to loosen. The liquor is now covered by 1 in. of water and left for three weeks or longer. The slower the crystallization the better is the quality of the product, here as in every other case where large crystals are desired. The best crystals are obtained from the sides; these when washed free from adhering mother liquor are with proper care nice enough for sale as lump alum to all but the most particular trade. The proportion of iron in them is below 0.05%. Next in quality come the crystals adhering to the lead strips; these can also be used directly for many purposes, but are liable to vary somewhat in quality and sometimes hold too much iron. The bottom consists of three layers, the first 1 to 1½ in. of very fine crystals mixed with gypsum or other insoluble matters carried over by the syphon; above this comes a white layer deposited simultaneously with the "sides" and, in case of well settled liquors, of nearly as good quality. The third layer consists of the last crystals formed in the liquor; these are present in all parts of the cooler, but being only loosely attached fall to the bottom, when the mother liquor is syphoned off. Being deposited from a liquor very much enriched in iron, the loose crystals of this top layer are the least pure of all and are only fit to be remelted.

When the crystallization is complete, which is known by the temperature of the mother liquor, the latter is drawn off into a lead-lined underground box and from there pumped by a steam syphon into a tank similar to the boiling tank used for concentrating the fresh liquor. The crystals are taken out and separated according to quality; those intended for direct sale as lump or ground alum, or in other shape, are washed and drained and the water is added to the mother liquors. The other salt is taken to the "roching" tank, where roching or remelting takes place. This is a round tank similar to the others already described, but preferably higher; 8 ft. diameter at the bottom, 7 ft. 4 in. at the top, and 7 to 8 ft. in height, are suitable dimensions. The lead used for the bottom ought here to be 12 lbs. and for the sides 8 lbs. to the sq. ft. Six 1-in. lead coils, each with its own supply valve, and an open 1-in. steam-pipe are provided for melting quickly the crystals shoveled in. The open steam-pipe together with the liquor left by the syphon from a previous operation furnishes enough water to dissolve the alum. About 20,000 lbs. of crystals constitute a charge. The contents of the tank are agitated from time to time and boiled until a strength of 48° Baumé is reached. About other methods of dissolving the alum in the roching process, see under "Alum shale." The operation is completed in 7 to 8 hours and the liquor is now covered with 6 in. of water and left to settle for 48 hours. At the end of that time it is syphoned into lead-lined cylindrical vessels 5 ft. high by 4 ft. in diameter. These are built in sections, the bottom in one piece and the sides in three pieces, which latter are provided with strong iron bands of suitable shape allowing the sections to be bolted together firmly. These sections are best built of narrow pieces of well-seasoned, straight-grained, 2-in. yellow pine. These pieces are held together by means of ⅜-in. bolts, securing them to the iron bands above mentioned. There should be on each side piece at least four, better five, bands made of 2-in. by ½-in. flat iron.

The 5-lb. lead used for lining the sections should be carefully dressed to

the wood, particularly on the edges where the sections are to meet each other. In connecting together, the bottom joints are made good by means of newspaper, afterward covered with a putty of plaster of paris; for the upright joints, strips of rubber 2 in. wide by $\frac{3}{8}$ in. thick are used, and here likewise a covering of plaster of paris is applied on the inside. If the sections are properly built, so that the faces meet each other squarely, and proper spaces be allowed between them, and if at the same time the bands are firmly bolted so as to prevent all "spring" or "play," which is particularly important at the bottom where the pressure is the greatest, everything will be tight. If leaks should occur, however, they may be stopped by throwing in fine crystals.

As soon as the plaster is properly set the settled liquor may be run from the rocher into the cylinder. After resting for 15 to 18 days the crystallization in these is complete. For the purpose of hastening the process, it is well to remove the sides after 10 or 12 days. In order to avoid too heavy bottoms which here, as in the coolers, yield a poorer alum than the rest, a few hangers may be used to advantage.

When the crystallization is complete a hole is made through the side of the block and the mother liquor, which now shows a strength of 16° to 20° Baumé, is run off and pumped into the mother liquor tank. If no sediment has been carried over from the rocher, all the alum with the exception of 1 or 2 in. at the very bottom, and some of the last crystals formed will be of prime quality. The crystals on the inside of the block, the loose ones as well as those on the sides in direct contact with the mother liquor, shortly the ones formed last, will possess a violet tints due probably to small traces of titanium sesqui-sulphate. As this color is objected to by the most particular trade, the alum so colored, as well as the inferior bottom layer, is generally separated and used for grinding.

The proportion of iron in the roched alum varies from 0.0015% in the best (the sides) to 0.005 or 0.01% in the colored crystals in the middle of the block. The free acid in the same way runs from a trace up to 0.05 and 0.08%. The residuum in the rocher after drawing off the clear solution contains besides sand and other insoluble matter a basic sulphate of alumina of about this composition: Moisture at 115° C., 22.40%; coarse sand, 3.90%; insoluble in dilute sulphuric acid, 9.68%; alumina soluble in dilute sulphuric acid, 16.00%. This analysis represented 500 lbs. of the residuum obtained from three rochings (54,000 lbs. finished product). The sand is from the coolers, into which it is thrown to stop leakages, when such occur. As soluble alumina is present to the extent of 16%, and ordinary potash alum only contains 9.91% alumina, it is evident that the sulphate of alumina is here present, either as anhydrous or basic. Unfortunately, the sulphuric acid was not determined and the writer is for that reason unable to decide that question. It is, however, generally assumed, that the basic salt is formed by the direct contact of the alum crystals with the hot steam-pipes. The fact that anhydrous potash alum contains only 19.90% alumina, while the above analysis, calculated upon substance free from moisture and insolubles, gives 25% alumina, confirms that theory. The total loss of crystallized potash alum in the above case amounted to 645 lbs. or 1.2%, figured upon the roched alum produced. To recover this alum, the residuum is put in the mother-liquor tank, where the excess of free acid soon dissolves out the basic sulphate.

The mother liquor from the coolers, which contains not only the free acid, the iron salts and other impurities traceable to the mixing operation, but also all the foreign salts introduced with the potash, is concentrated in the boiling tank provided for that purpose, together with other waste liquors, from its original strength of 25° to 30° Baumé up to 35° Baumé; during the last of this concentration there is more or less of hydrochloric acid evolved.

The proportion of free acid is now determined and a sufficient amount of finely ground American bauxite (it being the more soluble) is added to neutralize this acid as nearly as possible. As this causes the formation of an additional amount of sulphate of alumina in the liquor, it becomes necessary to add an amount of potash equivalent to this. After adding it, either as sulphate or muriate, or a mixture of both, and dissolving the same, the whole is boiled up to 40° to 42° Baumé, settled in the usual way, and run off to crystallize.

As nothing is gained by a slow crystallization in the case of mother liquors, a smaller cooler, affording quicker results, is preferred for these. These crystallizers may be made either square, say 12 ft. by 6 ft. by 1 ft. 6 in high, or wider at the top, tapering toward the bottom, say 12 ft. by 7 ft. at the top and 12 ft. by 1 ft. 6 in at the bottom by 3 ft. 6 in. high. In either case there should be a slight fall one way and an outlet pipe provided for the mother liquor. The latter construction has the advantage that in case of imperfectly settled liquor the solid impurities all accumulate in the comparatively small "bottoms" while the "sides" are clear of sediment.

The crystals obtained are strongly colored, either green or yellow, depending upon whether the iron is present in the ferric or ferrous state. They also contain considerable free acid besides some soda, lime, magnesia, chlorine and titanium. After the mother liquor is drawn off and the crystals drained as well as possible, they are taken, generally without previous washing, directly to the roching tank, where, if mixed with some of the purer first crystals, they may be remelted and produce a very satisfactory roched alum. As to the mother liquor, it is by this time quite rich in iron and will hardly pay to treat any more for the production of alum. Comparatively little alumina remains in it, and the sulphuric acid having been previously neutralized is chiefly combined with iron. We may, therefore, without suffering any great loss, allow this liquor to run to waste, or else work it for the production of copperas, provided, of course, that the iron is present as sulphate. In that case, it would seem most natural to heat the liquor with scrap iron until all the ferric oxide present is reduced to the ferrous state, and at the same time all or nearly all of the free acid neutralized, then to run off the solution and allow it to crystallize. If this is done no satisfactory results will be obtained, however. The copperas produced will contain considerable alum and be unsuitable for nearly all purposes except sewage precipitation. To avoid this admixture of alum or, may be, ferrous aluminum sulphate (FeO, SO_3, Al_2O_3, $3\ SO_3 + 24\ H_2O$) the treatment with scrap iron may be continued until not only all the free acid is neutralized, but also part of the alum converted into basic insoluble alum. The alumina may thus be largely precipitated as basic sulphate or basic alum, which can be separated by settling. This will, however, require considerable time and fuel in the shape of steam, and would probably prove unsatisfactory, as nothing would be obtained but copperas of greater or less purity.

A better way to treat these liquors is one that will be described under the manufacture of alum from alum-shale and aluminous earths.

Cost of Potash Alum Made from Bauxite.—

Bauxite, 3750 lbs. at $8 per 2240 lbs.	$13.39
Chamber acid, 50° Baumé, 9900 lbs. at 35c. per 100 lbs.	34.65
Sulphate of potash, 90%, 3300 lbs. at $2.10 per 100 lbs.	69.30
Water (provision made for return of condensed water and utilization of exhausts), 1000 c. f. at 75c.	.75
Coal, 5 tons cheap steam coal at $2.24 per 2240 lbs.	11.20
Labor	22.50
Superintendence	7.00
Repairs	6.00
Barrels (non-returnable), 40 at 24c.	9.60
General expenses	6.75
Product, 15,000 lbs. potash alum	$181.14

Corresponding to a yield of 400% upon the bauxite used; cost per 100 lbs., in factory ready for shipment, is therefore $1.21.

Manufacture of Potash Alum and Sulphate of Alumina from Alunite: The Italian Method.—The mineral is first roasted in order to decompose the basic sulphate into soluble neutral sulphate and insoluble alumina. This roasting is done in kilns similar to limekilns at Tolfa, or in heaps as done in Sicily, and is assumed to be completed when sulphurous and sulphuric acid fumes commence to escape. At that point the water of hydration held by the alumina is nearly all driven off, and experience has shown that that is all that is necessary to break up the basic sulphate. Properly burnt ore takes up water, while dead burnt ore does not. Below an analysis (*a*) by Brescius is given of too strongly burnt ore; column (*b*) represents properly burnt ore, assuming that all the water could be driven off; it is not an actual analysis, but is calculated from the crude ore, the composition of which is given in column (*c*).

	Per Cent.	Per Cent.	Per Cent.
Alumina (Al_2O_3)	(*a*) 57.334	(*b*) 41.86	(*c*) 38.3
Potash (K_2O)	14.447	7.86	7.2
Ferric oxide (Fe_2O_3)	1.219	Trace	Trace
Sulphuric acid (SO_3)	22.222	41.09	37.6
Silica (SiO_2)	2.437	8.96	8.2
Water (H_2O)	1.300	.....	8.5
	98.959	99.77	99.8

As 14.4% potash requires 15.06% sulphuric acid, we only have in (*a*) 7.16% sulphuric acid left over to combine with the alumina, of which only 3.07% can be taken up by this amount of acid to form neutral sulphate; 55.26% alumina will therefore remain behind as insoluble in water. Such a product is consequently unsuited for this method, but could be treated by the sulphuric acid process to be mentioned below.

(*b*) Even the properly burnt ore yields, according to the above analysis, under the most favorable circumstances, only 14% soluble alumina, so that nearly 28% will remain insoluble, assuming that the neutral sulphate has been extracted. As, however, the sulphate is more or less basic, the percentage of insoluble is somewhat less than 28%. Whether this insoluble alumina is utilized or not by solution in sulphuric acid for the production of either alum or sulphate of

alumina is not known to the writer. It would seem that by means of hydrochloric acid the iron might easily be extracted, and thus a pure alumina ready for further treatment be obtained.

The burnt material is ground and put in big reservoirs or cemented pits and dampened every day for two to three months. During this process alum is formed in an amount equivalent to the potash present. The dampened material is lixiviated in copper pans with water at 70° C., and the big undissolved lumps taken out to be returned to the kiln for reroasting. The settled liquor standing 10° to 12° Baumé is boiled to 32° Baumé and crystallized, during which process a very fine suspended ferric oxide deposits among the crystals as a pink sediment. This gives to the Roman alum its characteristic color, but stays behind upon recrystallization when neutral or cubic alum is obtained.

All the iron originally contained in the alunite, except the sediment just mentioned, stays behind as insoluble, or if any goes into solution it is precipitated by the excess of alumina present.

Cubic alum—alum in the form of cubes—can be obtained from ordinary alum by evaporating at ordinary temperature an alum solution holding some neutral (basic) alum. If made in this way it has exactly the same composition as the octohedric or common variety. To prepare artificially such Roman alum, a neutral alum solution is first made by adding enough carbonate of soda to form a small precipitate; this solution is then exposed to the air with frequent stirring, which causes the precipitated alumina to gradually separate out all the iron. The clear solution is next crystallized and some fine brickdust sprinkled over the alum while revolving in a drum.

Roman alum is chiefly distinguished for its freedom from iron, and is mostly used for fine cotton and silk dyeing. Medium grades holding 0.002% to 0.003% iron are unsuited for this purpose, even 0.001% being too high for particular work. Ferrocyanide of potassium should give no blue color in the cold for 12 to 24 hours in the best grades, as for instance the Neapolitan, which is absolutely free from iron. The best Roman alum holds less than 0.0005% soluble iron; the balance stays behind as insoluble in water.

The Neapolitan alum is obtained by dissolving the natural alum occurring at Solfatara, near Naples, in wooden tanks at 40° C. and crystallizing the solution. The alum thus obtained is then recrystallized, and yields the above very pure product.

In Hungary, at Munkacs, the alunite is worked as in Italy with very little difference. The kilns used here for roasting are nearly cylindrical, 6 ft. high over the grate and 5 ft. in diameter, slightly tapering toward the top. A charge of 10,000 lbs. is roasted in from 6 to 8 hours with a consumption of 20% of air-dried wood. The roasted mineral is left in heaps, 3 to 4 ft. high, during 6 to 8 weeks with frequent dampening. The mass is leached and the solution of 10° to 12° Baumé is concentrated in copper pans to 33° Baumé, settled and run off to crystallize. The alum thus obtained is dissolved in cast-iron kettles and recrystallized.

This method, on account of its slowness, although yielding as we have seen an excellent product, is gradually being abandoned and will soon possess only a historical interest. It cannot compete successfully with the manufacture from

bauxite. The same mineral is, however, worked by another process which utilizes all or nearly all of the alumina contained in it, a process which is in use in several large French works and which we will now describe.

The French Method.—The mineral is first dried and ground and is imported in that condition from Italy. The first operation at the French works is the calcining of the alunite. This is done at a temperature of 800° C. in a reverberatory furnace. The mineral by this process loses 23%, but all or nearly all its alumina and sulphate of alumina are now easily soluble in sulphuric acid and all its iron is converted into ferric oxide. If the temperature in the furnace has been too low the alunite is not so soluble; if it has been too high the loss of sulphuric acid is unduly large and the alumina will vitrify and become insoluble. The mineral is now treated like bauxite with sulphuric acid 52° Baumé, but in this case the acid is diluted with wash-liquors and mother liquors from the first crystals to 32° Baumé and heated to 80° to 90° C. The alunite is shoveled in gradually, and when the soluble material is properly extracted, which requires 2 to 3 hours' boiling, as much potash is added as is required to make up an amount of that alkali equivalent to the alumina contents of the alunite charged.

An analysis of the calcined product to ascertain its amount of soluble alumina and general composition determines the quantity of the acid and the potash to be used. The following analysis is by Guyot, who has investigated this process carefully:

	Per Cent.		Per Cent.
Potassium sulphate (K_2O, SO_3.)	14.00	or K_2O	7.56
Aluminum sulphate (Al_2O_3, $3SO_3$) as alum	26.55		
Aluminum sulphate (Al_2O_3, $3SO_3$) as such	6.56	Al_2O_3	28.51
Alumina (Al_2O_3), free	18.58	SO_3	29.62
Ferric oxide (Fe_2O_3)	0.80	Fe_2O_3	0.80
Water (H_2O)	11.90	H_2O	11.90
Silica (SiO_2), etc	21.61	SiO_2, etc	21.61
	100.00		100.00

For such a product, the following proportions are found suitable: 12,500 kilos sulphuric acid 52° Baumé, 8000 kilos calcined alunite and 2700 kilos sulphate of potash. This corresponds to 6625 kilos sulphuric acid (SO_3) and 2280 kilos total alumina, or 1486 kilos free alumina, or 1.44 molecules free alumina to 8.28 molecules sulphuric acid (SO_3), or 1 molecule free alumina to 5.75 molecules sulphuric acid (SO_3) leaving, therefore, an excess of 3158 kilos sulphuric acid, (SO_3) corresponding to about 5% free acid (SO_3) in the ready liquor. This alumina requires in all 3855 kilos sulphate of potash, of which there are already present 1120 kilos in the mineral, and we therefore have to add only 2735 kilos, which corresponds to Guyot's directions.

After adding the potash in the shape of solid sulphate of potash, the charge is heated and stirred to insure a proper solution. The liquor is now reduced to 42° Baumé, if above that density, and allowed to settle over night, covered by some water to avoid the separation of alum crystals, then drawn off and crystallized under frequent agitation. The mother liquor is used in the mixers, for it is quite acid, as will be seen from the proportions of raw materials used. The small crystals obtained are washed and the wash-water used for diluting

the acid in the mixers. The crystals are then remelted in the manner already described under the manufacture of bauxite. The solution of the melted crystals stands only 44° Baumé, however, and the alum obtained in the blocks is more uniform, the bottom being fully as good as the sides or even better. By remelting these, omitting the crystals last formed, on the inside of the block, alum absolutely free from iron is obtained.

Sulphate of alumina is also manufactured by this method. In that case the acid and the alunite are so proportioned that a solution nearly neutral is obtained already in the mixer. After settling and crystallizing out the potash alum present, this solution may be evaporated and an acid sulphate of alumina holding some iron be produced. If, however, a purer article is desired, it is necessary to precipitate most of the iron in some way. For this purpose the mother liquor from the crystallized alum is pumped back into the mixer and there treated with enough chloride of lime to oxidize any ferrous iron that may happen to be present, and boiled for several hours with a large excess of alunite, always taking care that all the iron is present in the ferric state. This treatment is claimed to precipitate almost all of the iron and after crystallizing out the extra amount of alum obtained from the second boiling with alunite and evaporating the solution to suitable strength a sulphate of alumina is thus obtained which is claimed to hold less than 0.1% of ferric oxide. The excess of alunite left in the mixer is utilized for the manufacture of alum by the method above described.

The yield of alum from this mineral is 3 to 3½ lbs., and of sulphate of alumina 2¼ to 2½ lbs. per pound of alunite.

Manufacture of Alum from Aluminous Earths and Alum Shale.—These two materials are chemically so similar that their treatment for alum production varies but very little in anything. In the case of the aluminous earths, which are very loose and porous and contain sulphur both in the free state and in the shape of iron pyrites, either a heap roasting followed by a further oxidation through long exposure to the atmosphere, "Verwitterung," is applied, or the order is reversed. The physical conditions of the earth, its amount of bitumen and free sulphur, etc., must determine which treatment is most suitable in each case. In the case of alum shale the ore is roasted at once, as this material is much denser and therefore atmospheric influences have much less effect upon it. The roasting is done either with or without additional fuel, depending upon the character of the ore. In the case of the Campsie shale, as already stated, burnt ore has to be added as the shale itself holds too much bitumen. It is important that the ores, if varying in composition, should be properly distributed in order to make the combustion uniform throughout the heap. All mineral containing lime and magnesia are avoided as causing a loss of sulphuric acid, and in the case of magnesia making the subsequent evaporation of the liquors difficult by the coating of sulphate formed on the surface of the heated liquor.

In England, at Whitby and Hurlet the slate is laid in small pieces in alternate layers with brushwood and coal upon a bed of well-pressed clay and ignited. By adding fresh material continuously the heaps are increased until they measure 200 ft. square by 90 ft. to 100 ft. high. Air channels are provided running throughout the length of the pile along the bottom and communicating with similar vertical channels. Thus air is admitted equally to all parts of the heap.

The temperature which sometimes rises quite high must be watched closely and is regulated according to circumstances by addition of spent ore, by sprinkling with water, by shoveling of the pile, or by addition of extra fuel. Too high temperature causes loss of sulphur as sulphurous acid; sulphate of alumina already formed may be decomposed, and slagging may occur. The right temperature is a low red heat only visible in the dark. Ore too little burnt gives liquors too rich in iron, too strongly burnt ore, liquors poor in sulphate of alumina.

In roasting the free sulphur forms sulphurous acid and the iron pyrites burns to monsulphuret of iron (FeS) and sulphurous and sulphuric acid. These acids by acting upon the clay form aluminum sulphite and sulphate. The iron monosulphuret with proper precautions is oxidized to FeO, SO_3 during the roasting, and that salt under subsequent exposure to the air forms basic ferric sulphate and free sulphuric acid, which produces another amount of sulphate of alumina. The latter quantity is lost if the roasted ore is immediately lixiviated. It is therefore generally left to the action of the atmosphere for a year or more after the roasting. The longer it is left the more sulphate of alumina and the less ferrous sulphate will be present in the aqueous extract. Some sulphates of lime and magnesia are also formed from the corresponding carbonates. Of these the former precipitates but the latter remains in solution.

The leaching is seldom done on the same spot where the roasting takes place, but the burnt ore is generally put into wooden tanks 30 or more feet square and 1 ft. to 3 ft. high, or in brick cisterns placed one above the other. The lye produced is generally held at 18° to 20° Baumé as a rule, but varies in strength according to the nature of the ore, prices of coal and labor, etc.

The liquors are clarified from gypsum, basic ferric sulphate, etc., by settling. This sediment is utilized by drying and subsequent roasting in shelf-burners, thus converting it into ferric oxide, of which various shades are produced and sold for paint.

The settled liquors now contain, beside sulphate of alumina, considerable amounts of ferrous and ferric sulphates, and smaller quantities of potassium, sodium, ammonium, magnesium, calcium and manganese sulphates, and chlorides of alumina and magnesia, and sometimes, if roasted at a low temperature, free sulphuric acid. The ferrous sulphate can be separated, at least partly, from the liquors, but the ferric sulphate cannot be got rid of, and will replace some of the alumina in the alum; to overcome this either an oxidation of the iron by means of "Gradirung," as applied in concentration of salt-brine, or by long standing, to basic potassic ferric sulphate, is resorted to, or else all the ferric iron is reduced by means of scrap-iron at a temperature of 15° to 20° C. The iron should be taken out when the reduction is finished.

The former method is slow and expensive; the loss of sulphuric acid and potash is too serious (an analysis by Seger of such basic iron compound gave 37.5% SO_3, 40% $Fe_2O_3 + Al_2O_3$, 9.8% K_2O, 2.3% CaO, SO_3, and 11.9% H_2O). When reducing to ferrous iron, the ferrous sulphate is removed by heating the liquor above 90° C., at which temperature the copperas is most soluble, and replacing the water evaporated gradually by fresh liquor, from which, when sufficiently concentrated, the ferrous salt precipitates (this takes place at 38° to 40° Baumé) while the sulphate of alumina remains in solution. As the proportion of the latter increases, the

ferrous sulphate becomes more insoluble. The boiling is kept up until the solution is saturated with sulphate of alumina, and is done in lead-lined brick cisterns, through which smoke-flues pass at a suitable distance from the bottom, or else in a reverberatory furnace.

Some gypsum and basic ferric sulphate are formed during this process, and even basic sulphate of alumina may form, particularly if metallic iron has been added to prevent the oxidation of the ferrous oxide, as then the iron decomposes the neutral sulphate of alumina under formation of ferrous sulphate and insoluble basic sulphate of alumina. These impurities are settled out, and the clear liquor is finally evaporated to 40° to 42° Baumé in lead pans heated from above. The strength of the final liquor should be such that the ferrous sulphate yet present will not crystallize out upon cooling, but remain in the mother liquor.

In case very much iron salt is present, the liquor is sometimes boiled to only 30° Baumé, the copperas crystallized out, and the mother liquor further concentrated to obtain alum. The boiling is continued until there is no further increase in strength. If at that point it should be found that upon cooling copperas will crystallize out, enough water must be added to prevent this from taking place. The settled concentrated liquor is finally drawn off and, after addition of potash, crystallized. Sometimes the potash-salt is added in the solid state just before the finishing of the liquor, but then plenty of basic potassic ferric sulphate is liable to form. During the crystallization the liquor is strongly agitated and the alum obtained in small crystals, alum-meal.

The alum-meal holds less of the impurities than the large crystals. As to the ferric alum contained in it, it is only got rid of by recrystallization. Less of this impurity is formed when an insufficient amount of potash has been used than when a full amount has been added. The alum-meal is washed in centrifugal machines making 800 to 900 revolutions per minute.

A lead sieve is used and all parts are covered with lead where in contact with the liquor. If the washed crystals now contain over 1% of iron alum they are re-crystallized before roching, otherwise they are at once roched.

The roching is done as described under the manufacture from bauxite; the crystals may be dissolved either by shoveling them directly into the boiling liquor in the roching tank, or the alum may be shoveled into a shallow round lead-covered box with perforated bottom suspended from and fitting closely to the sides of the roching tank. Underneath this box there are two large steam-pipes; the steam from these in condensing dissolves the alum. Or in place of this shallow box we may use a large lead funnel into which the alum is shoveled from above and the steam introduced from below in such a proportion that no steam escapes uncondensed; in this way large quantities of alum can be dissolved in a very short time. The solution is drawn off at a strength of 50° to 52° Baumé, into the blocks, which often are covered to retard the crystallization. If instead of using a funnel, an inverted cone made of lead properly supported and perforated with a large number of holes, say ¼ in. in diameter and 300 holes to the square foot, is used, all the basic alum formed will stop in the cone and the settling be materially facilitated.

Manufacture of Potash Alum from other Raw Materials.—Among these may be mentioned the New Jersey fire-clay occurring at Woodbridge, Raritan River,

Sand Hills, South Amboy, etc., which, owing to its freedom from iron, was formerly considered a very satisfactory material for the manufacture of alum; but owing to its comparatively low percentage of alumina it could not compete with the bauxite. The average composition of this New Jersey clay may be stated at 36% to 39% alumina, ½% to 1% ferric oxide, 1% to 1½% titanic acid, 44% to 48% silicic acid and 14% to 16% water.

Another material also suitable on account of its freedom from iron is kaolin. This is a hydrated silicate of alumina corresponding to the formula Al_2O_3, $2\ SiO_2 + 2\ H_2O$, or to 39.8% alumina, 46.3% silicic acid, and 13.9% water. All kaolins approach very closely to this composition, are free from titanic acid, and in case of the better grades hold only from traces up to 0.1% to 0.2% of ferric oxide. A material as free from iron as this would of course produce a very pure grade of alum, but being in large demand for porcelain manufacture and consequently commanding a high price it has not been extensively used for making alum.

The alumina in the kaolin as well as in the Jersey clay above mentioned is easily soluble in sulphuric acid. This is not the case with the different kinds of feldspar, which owing to their percentage of both alkali and alumina would be particularly desirable materials for alum manufacture were it not that the silicic acid is so firmly combined with the bases that it offers great difficulty to break the affinity.

The potash feldspar or orthoclase which corresponds in composition to the formula K_2O, Al_2O_3, $6\ SiO_2$, and holds 16.9% potash 18.5% alumina and 64.6% silica has been the object of many attempts at utilization to produce alum economically. Before the discovery of the immense potash deposits at Stassfurt, Germany, the inducement to experiment with this raw material was much greater, as it was then almost the only source of potash. By means of fluorspar and sulphuric acid, the silicic acid may be separated from the alkali and the alumina, but this, as well as other processes, has been found unprofitable, and so far no successful method has been devised to make available the immense quantities of alkali and alumina, which are locked up in the orthoclase and similar minerals.

Potash alum and sulphate of alumina have also been made from blast-furnace slag. For this purpose the slag is very finely powdered and treated with hydrochloric acid. This dissolves the alumina and the small amount of iron (generally no more than ½%) and generates sulphureted hydrogen by the action upon the calcium sulphide present in the slag. This causes the reduction of the iron to the ferrous state and the surplus sulphureted hydrogen is absorbed in water if needed for the later treatment. The solution of the chlorides is evaporated to dryness and further heated until the silicic acid has become insoluble; the remaining chloride of alumina is then converted into sulphate by means of sulphuric acid. This method makes no provision for the separation of the iron. To eliminate this impurity the solution of chloride of alumina may be precipitated by means of calcium carbonate or aluminate producing in either case chloride of calcium and hydrate of alumina. The iron, being in the ferrous state, remains in the solution. The precipitate is washed with the weak H_2S solution, mentioned above. The great difficulty in the latter case is the gelatin-

eous condition of the alumina. To precipitate this in a dense form is the difficult problem in connection with this process. From a slag containing 25% alumina, 42% lime and 31% silicic acid, Lürman* obtained 180 parts of sulphate of alumina by treating 100 parts of slag with 333 parts of muriatic acid, holding 34% HCl and 58 parts of sulphuric acid 62° Baumé.

Manufacture of Ammonia Alum. — This alum occurs as the mineral Tschermigite in Bohemia. Its properties and its mode of manufacture are almost exactly like those of the potash alum. Indeed, this alum very often is mixed indiscriminately with the former, so that potash alum very often contains a certain amount of ammonia alum. Sometimes, however, the pure ammonia alum is demanded, and for that reason there is more or less of it made.

Its composition is 3.75% ammonia, 11.35% alumina, 35.29% sulphuric anhydride, and 49.61% water. Its sp. gr. is 1.631, it is less soluble in water than the potash alum except at 100° C., where 100 parts of water dissolve 422 parts of ammonia alum, and only 357 parts of potash alum. When ammonia alum is heated, it swells and forms a porous mass, losing water and sulphuric acid, and burnt alum may be produced from it as well as from potash alum. Heated to a white heat it finally leaves only alumina.

The sulphate of ammonia, which is used for the production of this alum, contains when pure 25.76% H_3N. The commercial article holds about 25% H_3N and is sold on that basis. It contains as impurities traces of free acid, chlorine and lime, a large trace of iron, some insoluble matter and moisture ; 100 lbs. pure sulphate of ammonia yield theoretically 687 lbs. alum ; 100 lbs. 25% sulphate of ammonia yield theoretically 666.4 lbs. alum ; 100 lbs. pure sulphate of potash yield theoretically 545.4 lbs. alum and 100 lbs. 90% sulphate of potash yield theoretically 490.9 lbs. alum ; 70.3 lbs. 25% commercial sulphate of ammonia or 68.3 lbs. of the pure article are therefore equal in alum-producing capacity to 100 lbs. 90% sulphate of potash.

Some of this alum is always found in the potash alum made from alum shale, the ammonia there owing its origin to the coal used for igniting the shale. If wood is used for this purpose, a certain amount of sulphate of potash instead is obtained from its ashes giving rise to a corresponding amount of potash alum.

Manufacture of Soda Alum.—Soda alum occurs as a mineral in South America. One deposit occurs at Mendoza, another in southern Peru. Thomsen has furnished the following analysis of these, which we give, together with the composition of the pure alum :

	Mendoza Deposit.	Southern Peru Deposit.	Pure Soda-Alum.
	Per Cent.	Per Cent.	Per Cent.
Alumina (Al_2O_3).....	12.4	22.55	11.2
Sulphuric acid (SO_3).....	37.7	36.60	34.9
Soda (Na_2O).....	7.5	2.85	6.8
Water (H_2O).....	42.4	39.20	47.1
	100.0	101.20	100.0

If these analyses are representative of the deposits it is readily seen that the Peru mineral is a basic sulphate of alumina, rather than a soda alum.

* *Dingler's Journal*, Vol. CXLIX.,, p. 351.

Soda alum would be produced in preference to either of the other two, sulphate of soda being so much cheaper than either the potash or the ammonia salt, were it not for the difficulty of crystallizing it. The properties of this alum are the same as those of the other two with the difference that this is very much more soluble in water. Its sp. gr. is 1.667. At 16° C. 100 parts of water dissolve 51 parts of the alum. Another difference is that when the alum contains an excess of sulphate of soda the crystals effloresce and fall to powder in the air, otherwise it is very little changed by exposure to the atmosphere. The great difficulty of crystallizing soda alum makes the ordinary methods unavailable. It has been found that the ordinary method instead of producing large and hard crystals yields a fine magna or an amorphous paste containing no crystals whatever, from which it is impossible to separate the mother liquor.

To overcome this difficulty, Spence in 1881 invented (English patent No. 5650) and in 1890 (English patent No. 448) further improved the following process for its manufacture: A solution of sulphate of alumina, neutral and as free from iron as possible, was mixed with an equivalent amount of sulphate of soda and heated with addition of enough water to make the strength 29° Baumé, measured hot. This when cold gave a saturated solution of soda alum, which was used for cooling another soda alum solution showing 45° Baumé when hot. By the mixing of these two liquids in suitable proportions and subsequent continuous stirring the temperature was reduced to 17° C. and no magma formed, or if formed was changed into good crystals. Spence later found that the same result could be obtained if the hot 45° Baumé liquor was stirred in a layer 6 in. deep, and the magma thus formed turned over with shovels until it showed signs of changing into crystals. Too much handling of the paste should be avoided, otherwise too small crystals are obtained.

Another process for making soda alum is Augé's (French patent No. 201,440). This chemist in 1890 investigated soda alum and corrected a number of misstatements about it, current in chemical literature up to that time. He found that a solution of soda alum does not, as supposed at that time, lose its power of crystallizing when boiled. If not concentrated above 38° Baumé the solution deposits crystals upon cooling, but if boiled above that strength the magma or paste is formed. This, however, is gradually transformed into the crystals by keeping it at a temperature of 17° to 25° C., best on an inclined lead-lined platform to enable the mother liquor to run off as the crystals form. At about 0° C. sulphate of soda also crystallizes out, producing an efflorescent soda alum.

The latest improvement in this line is that of J. S. Kessler (English patent No. 2710, Feb. 7, 1893). This chemist found that either the large crystals or the cheesy magma could be produced from crystallizing liquors by simply introducing the one or the other kind of crystals. He described several processes whereby he obtains the large crystals. One of these consists of introducing into the magma already formed some of the true alum crystals, when the mass becomes transformed throughout without stirring into the desired form of crystals. Another method is to allow a boiling solution of sulphate of alumina to cool to 90° C. then to add cold mother liquor or a cold saturated solution of soda alum 40° Baumé, thus cooling the whole to 40° C., and finally to add the

sulphate of soda crystals required by the alumina present. The "zone of dangerous temperature," at which the magma is formed, is thus safely passed and on cooling the true crystals are deposited. The same inventor gives other methods for producing this alum in the shape of hard crystals. For these we must refer to the patent specifications. The purification of the crystals is effected by continuous washing by processes of displacement as used in lixiviating crude soda.

For the production of this alum Kessler takes up the proposal already patented in 1883 (Swedish patent No. 3) of heating clay or bauxite with bisulphate of soda (niter-cake) and sulphuric acid. The object of that invention was to utilize the niter-cake for the purpose of taking the place of the sulphuric acid. The Swedish chemist for this purpose enriched his niter-cake solution as much as possible by crystallizing out the sulphate of soda. The finely ground clay was now dissolved in the acid sulphate of soda and the clear solution obtained concentrated and crystallized in order to separate the sulphate of soda contained in it as Glauber's salt. The mother liquor was then further concentrated with addition of potash salt, thus forming potash alum and more sulphate of soda. The alum was now crystallized out and the mother liquor further concentrated to separate out as much as possible of the sulphate of soda formed by the addition of the sulphate of potash. The final mother liquor, which now contains beside some potash alum and sulphate of soda the most of the free acid and the ferric sulphate, may be used again in the mixer to dissolve the aluminous mineral until it becomes too rich in iron.

Manufacture of Chrome Alum.—Of the three chrome alums only the potassium alum is of importance. The composition of this is K_2O, $SO_3 + Cr_2O_3$, $3\ SO_3 + 24\ H_2O$. It crystallizes in dark purple almost black octahedra. It is soluble in 7 parts of water with violet color, which changes to green by heating the solution to 75° C. A chrome-alum solution thus heated does not crystallize upon cooling, but upon long standing the solution again becomes violet and capable of crystallization. The crystals lose one-half of their water at 25° to 30° C. and become lilac in color; heated to 100° C. they lose more water and turn green; at 350° C. all the water escapes, but the salt is yet soluble in water. Above 350° C., however, it changes color and becomes insoluble in water.

This salt is best made by adding five parts of strong sulphuric acid to a solution of three parts of commercial bichromate of potash in 30 parts of water, and conducting sulphurous acid through the solution, taking care to avoid all heating. As a reducing agent alcohol can also be used, but in that case more sulphuric acid is required; aldehyde and acetic acid are formed at the expense of the chromic acid. In either case the sulphate of the sesquioxide of chromium is formed, which, combining with the sulphate of potash formed by the action of the sulphuric acid upon the bichromate of potash, forms chromic alum, as expressed by the following formula :

$$4\ (H_2O,\ SO_3) + K_2O,\ 2\ CrO_3 + 3\ SO_2 + 24\ H_2O = K_2O,\ SO_3 + Cr_2O_3,\ 3\ SO_3 + 24\ H_2O + 3\ (H_2O,\ SO_3) + H_2\ O.$$

This alum is also obtained as a by-product from many manufactures of organic substances where a mixture of sulphuric acid and bichromate of potash has been used for oxidizing purposes.

Applications of Alum.—These are many and important. Owing to the great affinity of the hydrate of alumina for textile fibers, particularly cotton and wool, alum as well as sulphate of alumina are used largely to fasten coloring matters on the fibers. On this affinity also depends its use for the production of lakes, which are compounds of a pigment with alumina. In fastening alumina to the fiber it is generally used in the form of acetate, which is produced from the sulphate by addition of acetate of lime or acetate of lead.

For these purposes it is very important that the alum should be free, or nearly free from iron, as ferric oxide precipitated upon the cloth is very hard to remove, and, as has been already stated under Roman alum, only the very purest alum can be used for particular work of this kind.

Another very important application of all kinds of alum is for sizing paper. According to the quality of the paper aimed at, the alum or sulphate of alumina used is more or less pure. Thus for newspaper a very crude kind of sulphate of alumina may be used, while for the very best grade of writing paper only the purest product is available. For this reason, it took sulphate of alumina a long time to make its way against the crystal alum. The latter being practically free from iron and uniform in quality, the paper-maker felt safe in depending upon it and was naturally unwilling to substitute for it an article, which very often varied considerably in quality. With more improved methods of manufacture and more uniform composition of the product, the chemical manufacturers have, however, succeeded in overcoming this prejudice, so that now very large quantities of sulphate of alumina are used for sizing even the best grades of writing paper. It has been found that for this purpose the sulphate of alumina, can without harm, contain 0.1% to 0.2% of iron, but this must be present in the ferrous state. The sizing of the paper is effected by the sulphate of alumina decomposing the size, which in this case is a rosin soap, so that sulphate of soda and an insoluble aluminous compound of rosin are formed. The latter in precipitating envelops the fibers, binding the same together, and makes the paper to a certain extent impenetrable to water.

Alum is also used for the hardening of articles made from gypsum and for the purification of tallow, in tanning white skins, and finally in the precipitation of sewage and the purification of water. The latter application depends upon the fact that a solution of alum if diluted sufficiently, as already stated, precipitates with the formation of basic salt, which in precipitating envelopes the suspended solid particles contained in the sewage or the water, carrying down not only these but also coloring matters and probably other organic substances coagulated through the action of the alum upon them.

For all purposes where alum is used, sulphate of alumina and potash-soda and ammonia-alum all act alike, granting that the solutions are of equal strength and purity; in every case the sulphate of alumina is the active agent and the alkaline sulphate simply goes to waste.

Chrome alum like the other alums is used in dyeing as a mordant; it is also used in calico printing and in tanning.

Sodium aluminate was formerly used in considerable quantities as a mordant and for the production of lakes, the solution in the latter case being mixed with coloring matters and precipitated with sulphuric acid; these lakes were said to

be superior to those obtained from alum and could be produced at only half the cost. At present it is very little used for these purposes, the reason being probably the great liability of the solution to deposit alumina and form a basic aluminate.

It has also been used for the production of artificial stone and instead of caustic soda for the saponification of fat. In the latter case alumina-soap is formed, which, treated with acetic acid, gave acetate of alumina and free fatty acid.

ALUM PRODUCTION.

The production of alum in the United States is in the hands of a few concerns, and reports are not generally made. The statistics of production given below have been chiefly obtained by calculation from the combined imports and production of bauxite and cryolite, allowance being made for the small quantity of those minerals used in the manufacture of aluminum. The imports are from the official returns.

PRODUCTION AND IMPORTS OF ALUM AND SULPHATE OF ALUMINA, REDUCED TO ALUM.
(In tons of 2000 lbs.)

PRODUCTION.				IMPORTS.							
Year.	Short Tons.	Value.		Year.	Short Tons.	Value.		Year.	Short Tons.	Value.	
		Total.	Per Lb.			Total.	Per Lb.			Total.	Per Lb.
1882.....	18,000	$720,000	$0.02	1870.....	1,243	$39,669	$0.016	1883....	848	$21,126	$0.012
1883.....	17,500	743,500	.02125	1871.....	2,356	74,450	.015	1884....	731	19,497	.013
1884.....	19,000	712,500	.01875	1872.....	1,998	64,465	.016	1885....	1,107	34,707	.016
1885.....	40,000	1,400,000	.0175	1873.....	2,109	66,243	.016	1886....	1,035	35,343	.017
1886.....	45,000	1,350,000	.0150	1874.....	2,027	67,913	.017	1887....	1,844	54,008	.015
1887.....	45,000	1,575,000	.0175	1875.....	3,476	112,516	.016	1888....	3,192	82,064	.013
1888.....	50,000	1,750,000	.0175	1876.....	3,633	103,152	.014	1889....	3,106	66,557	.011
1889.....	70,000	2,450,000	.0175	1877.....	4,130	112,275	.014	1890....	3,411	94,043	.014
1890.....	85,000	2,620,000	.0154	1878.....	4,328	107,394	.012	1891....	2,326	58,864	.013
1891.....	74,000	2,220,000	.0150	1879.....	2,981	65,708	.011	1892....	2,070	59,336	.014
1892.....	86,000	2,580,000	.0150	1880.....	1,056	24,435	.011	1893....	2,286	73,806	.016
1893.....	96,000	2,880,000	.0150	1881.....	1,043	22,331	.011	1894....	919	30,832	.016
1894.....	72,000	2,160,000	.0150	1882.....	1,243	29,939	.012				

The rate of duty on alum imported was 0.6c. per lb. for all the years shown in the table up to 1894; in August of that year it was reduced to 0.4c. per lb.

The exports of alum and sulphate of alumina are not given separately in the government reports. Our export trade in these articles however, is very small.

Austria.—The production of alum and sulphate of alumina in Austria was as follows, according to the official statistics reported from 1879 to 1892 inclusive. The table also gives the imports and exports from 1886 to 1892; in the imports and exports chloride of alumina is included in sulphate of alumina.

PRODUCTION, IMPORTS AND EXPORTS OF ALUM AND SULPHATE OF ALUMINA IN AUSTRIA.
(IN METRIC TONS AND DOLLARS.)

PRODUCTION.						IMPORTS.			EXPORTS.	
Year.	Tons.	Value.	Year.	Tons.	Value.	Year.	Alum.	Sulphate of Alumina.	Alum.	Sulphate of Alumina.
1879.....	1,972.5	$55,291	1886.....	1,808	$44,112	1885....	288.7	379.2	182.2	26.5
1880.....	2,103.8	57,592	1887.....	2,129	54,088	1886...	377.5	392.1	182.5	25.5
1881.....	2,040.4	50,317	1888.....	1,683	43,185	1887....	267.4	492.8	62.4	30.4
1882.....	1,965.9	45,748	1889.....	1,547.5	38,863	1888....	375.5	518.1	52.9	91.3
1883.....	1,732.4	43,411	1890.....	1,463.6	35,063	1889....	346.9	274.7	39.7	3.8
1884.....	1,916.6	46,966	1891.....	1,126.6	25,647	1890....	300.3	205.8	118.0	11.5
1885.....	1,949	45,330	1892.....	1,095.6	24,116	1891....	211.9	307.5	92.6	17.0
						1892....	159.4	191.0	79.3	25.9

There are seven factories in operation in Austria which make alum and sulphate of alumina. The manufacturers have not extended their business and do not seem able to stand the German competition.

France.—The production of alum and sulphate of alumina in France is not obtainable from the official statistics, but the imports and exports were as follows:

IMPORTS AND EXPORTS OF ALUM AND SULPHATE OF ALUMINA IN FRANCE.
(IN METRIC TONS AND DOLLARS.)

IMPORTS.			EXPORTS.		IMPORTS.			EXPORTS.	
Year.	Tons.	Value.	Tons.	Value.	Year.	Tons.	Value.	Tons.	Value.
1880.....	159.4	$31,886	2,004.3	$73,171	1886.....	2,476.7	$116,788	2,321.6	$79,607
1881.....	132.4	26,468	1,760.5	66,932	1887.....	2,908.6	98,891	1,777.6	60,437
1882.....	1,101.5	45,856	2,613.3	94,339	1888.....	3,611.0	122,773	1,651.0	56,133
1883.....	1,611.7	78,023	3,256.6	111,773	1889.....	3,911.9	93,182	1,710.2	54,726
1884.....	1,494.0	70,320	2,415.0	83,079	1890.....	2,248.8	62,966	1,236.6	37,097
1885.....	1,865.2	93,993	2,777.1	95,599	1891.....	3,109.7	87,071	1,153.9	34,614

PRODUCTION OF BAUXITE IN FRANCE. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Tons.	Value.	Price Per Ton.	Year.	Tons.	Value.	Price Per Ton.
1885.....	19,100	$50,400	$2.64	1889.....	19,000	$35,600	$1.87
1886.....	.....	.....	.....	1890.....	19,000	35,600	1.87
1887.....	20,500	33,000	1.61	1891.....	22,000	38,200	1.74
1888.....	19,000	37,800	1.99	1892.....	23,000	39,400	1.71

(*a*) From *Statistique de l'Industrie Minéralé en France.*

As the production of bauxite was nearly stationary while increasing amounts of the mineral were exported, we may conclude from the above tables that the French alum industry has not increased since 1886. There is a duty on alum of $1 per 1000 kilos, and important improvements have been made by French chemists from time to time. In 1893 there were 16 alum works in operation in France.

Germany.—The production of alum and sulphate of alumina in Germany is given in the following table:

PRODUCTION OF ALUM AND SULPHATE OF ALUMINA IN GERMANY.
(IN METRIC TONS AND DOLLARS.)

Year.	Alum.		Sulphate of Alumina.		Year.	Alum.		Sulphate of Alumina.	
	Tons.	Value.	Tons.	Value.		Tons.	Value.	Tons.	Value.
1873.....	2,445	$107,175	370	$16,184	1883.....	3,620	$120,476	18,273	$394,380
1874.....	2,495	108,628	500	20,825	1884.....	4,164	134,646	16,679	380,593
1875.....	3,886	169,300	400	17,136	1885.....	3,880	124,948	20,313	448,295
1876.....	3,660	146,720	400	17,136	1886.....	3,223	99,343	19,463	419,605
1877.....	3,953	152,687	442	14,744	1887.....	3,777	114,456	21,930	463,910
1878.....	3,731	141,253	.....	.....	1888.....	3,999	124,023	24,641	509,468
1879	3,771	133,144	2,342	66,952	1889.....	4,215	129,007	24,929	475,804
1880.....	4,708	168,292	12,819	381,300	1890.....	4,460	130,289	31,010	527,565
1881.....	5,068	176,300	12,837	339,970	1891.....	5,619	130,985	28,710	515,800
1882.....	3,855	131,883	14,519	363,552	1892.....	4,270	111,860	28,388	521,934

Previous to 1873 there was practically no sulphate of alumina manufactured in Germany; the figures given in the table will show how rapidly that production has grown.

The exports of alum increased rapidly. In 1873 they amounted to 730 metric tons; in 1880 to 3215 tons; in 1885 to 7812 tons; and in 1890 to 13,781 tons. Since then the growth has been still more rapid, and the total exports were 15,017 tons in 1891; in 1892 they were 15,895 tons, and in 1893, 18,392 tons.

The imports have never been large; they decreased steadily from 11,140 tons in 1873 to 226 tons in 1883; during the next six years they varied slightly, but the highest figure for any one year was 460 tons, and in 1891 it was 157 tons. In the following year there was a slight increase to 262 tons, and the amount was further increased to 363 tons in 1893. There is an import duty of 30 marks ($7.50) per ton on alum imported into Germany.

The tables give a pretty good illustration of the growth of the German industry and show it to be in an excellent condition. When it is remembered that the bauxite deposits of Germany are as a rule inferior to those of France in both quality and quantity, so that many German manufacturers import their bauxite, it will be acceded that the prosperous condition of the industry in Germany is due not so much to cheap labor and raw material as to the application of scientific methods. In 1894 there were 21 alum works in Germany beside 8 factories making only hydrate of alumina. Recently some bauxite from this country has been sent to Germany.

Italy.—The production of alum and sulphate of alumina in Italy is given in the table below. The imports rose steadily from 420 metric tons, valued at $14,277 in 1880, to 2866 metric tons, valued at $68,791 in 1892. During the same period the exports decreased in very nearly opposite ratio. In 1880 they were 2432 tons, valued at $82,691, while in 1892 they were only 134 tons, valued at $3214. The industry in Italy shows a steady decrease in spite of the extensive deposits of alunite at Tolfa and elsewhere. Prior to 1885 the industry was fairly prosperous, but apparently the Italian makers have not been able to hold their own against the French bauxite; or else as is possible that the methods in use in Italian factories could be improved.

PRODUCTION OF ALUM AND SULPHATE OF ALUMINA IN ITALY.
(IN METRIC TONS AND DOLLARS.)

Year.	Alum.		Sulphate of Alumina.		Year.	Alum.		Sulphate of Alumina.	
	Tons.	Value.	Tons.	Value.		Tons.	Value.	Tons.	Value.
1880.....	4,443	$151,114	750	$27,000	1886.....	5,320	$39,760	440	$8,160
1881.....	1,400	42,400	.....	.....	1887.....	2,260	57,400	1,980	34,000
1882.....	4,225	137,460	1,430	32,230	1888.....	1,380	31,581	2,825	43,722
1883.....	3,425	.....	1,270	.....	1889.....	1,380	30,120	2,667	61,248
1884.....	3,115	89,360	1,780	32,480	1890.....	1,294	26,276	2,553	58,430
1885.....	2,950	83,200	630	12,800	1891.....	1,029	20,080	859	17,168

United Kingdom.—The mineral statistics of Great Britain give only the production of alum-shale and alum-clay or bauxite. No figures can be obtained as to exports or imports of alum. There are large quantities made, however, and last year there were 33 factories in operation producing alum.

Other Countries.—Of the other European countries there is very little to be said. As long ago as 1862 Spain produced a considerable quantity, 2252 metric tons being reported in that year. Since then, however, the industry has almost

ceased, and for a number of years it has averaged less than 400 tons a year. In Belgium there are five alum factories and in Sweden four, and both countries produce a considerable quantity. In Denmark there are two factories, both of them working the cryolite from Greenland.

Russia has developed a considerable alum manufacture. There were nearly 14,000 metric tons produced in 1886, and the amount has increased considerably since then, although complete statistics are not obtainable.

CONDITION OF THE INDUSTRY IN THE UNITED STATES.

The chief demand for alum in this country has so far been in the East. As a consequence the factories are all concentrated in a comparatively small area and there is a competition which is felt particularly in times of financial depression. The location of nearly all the paper mills and other large consumers of alum in the East has caused the alum manufacturers to locate there. The paper industry consumes 50% or more of all the alum manufactured while it is estimated that 30% are used in dyeing, calico printing and allied industries. About 15% may be used for filtering and purification of water, while the remaining 5% is used for tanning and miscellaneous purposes.

In consequence of the competition the alum business was not very satisfactory during 1893 and 1894. It has suffered along with other trades, and from the same causes. With the return of confidence in the commercial and manufacturing world the products of all the Eastern factories should again be readily absorbed. There is no reason to assume that there should not be a bright future ahead for this industry. The quantities required for sewage disposal and water purification must of necessity increase, and with the growth of the West and South, paper mills, print works and dye-houses will multiply in those sections, and a demand for alum arise which can best be satisfied by the erection of alum works there. The bauxite fields being situated in the South, that part of the country seems a natural place for alum factories, especially as sulphuric-acid works are scattered in large numbers over all the phosphate-producing States.

In various parts of the West we find natural deposits of soda-alum and sulphate of alumina, most of them too small and too far removed from transportation lines to be of present importance. Besides the Wyoming deposits there is, at least, one bed of such magnitude and so situated that sooner or later it is bound to play an important part in the western alum market. This deposit is situated in Grant County, New Mexico, on the Gila River, and covers 1250 acres. Some parts of this bed are very rich in sulphate of alumina, but it has not been fully explored, nor have sufficient analyses been made. These Western deposits, however, will certainly have a great influence upon the trade hereafter.

In short, with our supplies of bauxite of excellent quality and of other raw materials, with cheap fuel and other natural advantages, it does not seem visionary to believe that the United States will, in the near future, not only supply its own needs, but also be able to furnish a considerable surplus for export.

ANTIMONY.

THE production and uses of this metal, together with the methods adopted in its reduction, were very fully treated in Vols. I. and II. of THE MINERAL INDUSTRY. To the information there given there is practically nothing new to be added as far as the metallurgy is concerned.

In production antimony, like many other minerals and metals, suffered from the continued depression in all branches of trade during the year, a small demand being met by a decrease in the output. The ore used in the United States during the year came almost entirely from the mines at Bernice in Nevada, at Caliente in California, and at Kingston in Idaho. At the latter place the works of the Idaho Antimony Company, which were started in 1893, continued in successful operation. The Arkansas mines were idle throughout the year, and produced no ore, although some development work was done on a new discovery in Sevier County. The mines at Big Creek in Nevada were also idle, as were all the California producers except those at Caliente. No report has been received from the mines of the United States Antimony Company in Montana, and it is understood that they were also shut down. The following table shows the production and imports of antimony ore and metal for five years :

Year.	Production.				Imports.	
	Metal.		Ores.		Ores and Metal.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1890	258,000	$40,756	720,000	$21,600	3,926,799	$441,838
1891	556,000	47,007	1,400,000	45,500	4,692,232	425,082
1892	400,000	36,000	1,700,000	51,000	4,143,208	400,099
1893	700,000	63,000	1,700,000	41,000	.....	.....
1894	440,000	39,000	330,000	9,075	1,205,752	79,265

The imports are from the reports of the Bureau of Statistics of the Treasury Department, and these statements included ore and regulus together. The production for 1894 is from the reports received from the producers.

The amount of metal produced in 1894 would require about 570 tons of ore of the grade usually purchased by the smelters. Of this quantity 165 tons were furnished by the production stated above, and 50 tons of imported Japanese ore were used by the smelters, making a total of 215 tons, so that the remaining 355 tons were drawn from the accumulation of ore mined in previous years.

Previous to the business depression of 1893 the production of antimony was increasing considerably, and there can be no doubt that as this depression passes away the business will revive and continue to grow in importance.

The following table shows the production of antimony ore in the world for the five years ending with 1894, as far as can be ascertained:

PRODUCTION OF ANTIMONY ORE. (IN METRIC TONS.)

Year.	Austria.	Canada	France.	Greece.	Hungary.	Italy.	Japan	Mexico.	N. S. Wales.	New Zealand.	Queensland.	Spain	United States.	Victoria
1890	770	23	4,962	564	224	891	1,895	86	1,043	523	175	820	327	132
1891	333	9	5,316	210	.....	782	2,268	2	930	421	220	693	635	67
1892	97	.....	5,103	425	853	621	2,814	.....	740	370	26	395	744	299
1893	441	.....	7,200	.....	881	1,193	1,649	9	1,803	336	30	88	771	89
1894	.....	.....	.....	.....	.....	.....	.....	35	.....	.....	.....	.....	150	.....

Antimony is produced also in other countries from which it is impossible to obtain accurate returns. A considerable amount is mined in the island of Borneo, but no statement of the amount can be presented. Portugal produces antimony ore, most of which is sent to Great Britain, and some ore is also obtained from Servia, although mining in the last named country is irregular and the quantity very uncertain. Recently antimony has been mined in considerable quantities in Chile, Peru and Bolivia. In 1892 there were 286 tons exported from Peru, and since then the amount has increased. The production in Australia and in Europe has fallen off to some extent, owing to the quantity of South American ores imported, which have been furnished in most instances at a lower price than the European product could profitably be furnished for.

The latest discovery of antimony ore noted is in Tonkin, where explorations made since the occupation of the country by the French have shown abundant deposits of stibnite in the northeastern part of the country between Quan-Yuen and Moncai. Other deposits have also been found on the Song-ma River, near the boundary between Tonkin and Annam. The discovery was first made by Chinese miners and confirmed by the explorations of the French engineers. The ore was first found in torrent beds, in rounded stones or boulders of varying dimensions, having a peculiarly smooth yellowish-brown surface. These stones when broken were found to contain a very rich sulphide. The Chinese who were the discoverers mistook this shining ore for silver until the smelting process was applied. Some desultory mining has been commenced in the Quan-Yuen region, but thus far no systematic work has been undertaken, owing to the unsettled condition of the country, which is liable to continuous irruptions from bands of Chinese robbers. When the district is settled and fully garrisoned, doubtless further operations will be undertaken, since a portion of the mining property has been claimed by some of the French companies organized to work for coal and other minerals in Tonkin. The local circumstances are rather in favor of mining, as the district is easily accessible, the country is more healthy than in the region near the coast, and labor can be obtained at a very cheap rate.

It may be stated, however, that there is no special inducement at the present time to open new deposits of antimony ore as the supplies from the regions already known appear to be sufficient and the price has for several years been decreasing.

The New York Antimony Market in 1894.

There has been scarcely any feature in the market worth mentioning, except that the production in California has been on the increase, and consignments have been received from there during the year in steadily increasing quantities. It has also been understood that importations of Italian and Japanese antimony have been made to a certain extent.

The quality of some of these products is said to be very good indeed, and consumers are taking these brands up owing to the cheaper prices. English makers have remained comparatively very firm and resisted the decline in prices as far as they could. Nevertheless, prices gradually declined. The year commenced with Cookson's quoted at 10c., L. X. 9½c., and Hallett's at 9c. The middle of the year Cookson's was held at 9¼c., L. X. 8¾c., and Hallett's 8½c. At the end of August the duty of ¾c. hitherto imposed was taken off, and consumers had the full benefit of this saving. Nevertheless, a further weakening set in, and at the end of the year prices closed very flat indeed, with Cookson's at 8½c., L. X. nominally 7¾@8c., Hallett's 7¼c., and inferior brands about 7c. For larger quantities slight concessions are obtainable all around.

AVERAGE MONTHLY PRICES OF ANTIMONY IN NEW YORK, IN CENTS PER POUND.

Year.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1891....	Cookson's	.19	18	.17⅛	.17⅛	.16	.14½	.13⅝	.12	.11⅝	.13¼	.16	.16¼	.15½
	Hallett's	.16½	.16¾	.16	.15½	.14¾	.13	.12	.10⅝	.10	.11	.12¼	.12¾	.13½
	L. X.	.17⅛	.17	.16¾	.16	.15⅛	.13⅝	.12½	.11⅜	.10⅝	.12	.15¼	.15⅛	.14⅜
1892....	Cookson's	.15⅞	.15	.14 9/16	.15	.15⅛	.14 ⅜	.14 ⅛	.13½	.11½	.11 ⅛	.12	.11½	.13¾
	Hallett's	.14 ⅜	.11	.10 9/16	.11	.11½	.11¼	.11	.10¾	.10½	.10½	.10⅝	.10¾	.12 1/16
	L. X.	.12⅛	.12⅛	.12½	.12⅛	.13	.12¾	.12½	.11⅞	.11¼	.11 ⅛	.11⅛	.10 ⅜	.12
1893....	Cookson's	.11	.10¾	.10¾	.10¾	.10⅛	.10½	.10½	.10¼	.10 3/16	.10¼	.10	.10¼	.10½
	Hallett's	.10¼	.10⅜	.10	.10	.10	.9 9/16	.9⅞	.9¾	.9 ⅜	.9¾	.9½	.9¼	.9⅞
	L. X.	.10½	.10⅝	.10⅜	.10¼	.10⅜	.10	.10⅛	.10	.10	.10	.10	.10	.10 ⅛
1894....	Cookson's	.10¼	.10	.10⅛	.10⅛	.10⅛	.9¾	.10	.10	.9⅛	.9⅝	.8½	.8⅜	.9⅝
	Hallett's	.9½	.9⅜	.9½	.9⅜	.9¼	.9⅛	.8¾	.8⅞	.8⅞	.8¼	.8¼	.8⅛	.8⅞
	L. X.	.9⅛	.8⅞	.8⅞	.8⅞	.8¾	.8⅝	.8⅜	.8¼	.7⅝	.7½	.7⅜	.7⅜	.8⅛

The London Antimony Market in 1894.

The year 1893 witnessed a fall of £5 in the price of this metal—from £42 10s. to £37 10s. During the first half of 1894 the value of regulus underwent a gradual but, in the aggregate, a serious depreciation of the already low values, £31 15s. being ultimately done, showing a fall of nearly £6 per ton, due in part to the very general depression in most industries and in part to a falling off in the demand for the metal. The fact that the supply of ores has been decidedly on the decrease did not prevent the decline, but this scarcity of raw material becoming more marked, in June smelters grew firmer in their ideas, and the value steadily recovered until in November £33 10s. was paid. The year closed, however, with a very quiet market at £32@£33 per ton.

VALUE OF ANTIMONY REGULUS IN LONDON.

Year.	Low.	High.	Year.	Low.	High.	Year.	Low.	High.	Year.	Low.	High.
1875.....	£50	£59	1880.....	£60	£75	1885.....	£35	£39	1890.....	£70	£76
1876.....	55	69	1881.....	55	60	1886.....	29½	35	1891.....	40	72
1877.....	48	50	1882.....	42	55	1887.....	30	40	1892.....	43	52
1878.....	48	50	1883.....	36	40	1888.....	39	50	1893.....	37	43
1879.....	50	70	1884.....	40	45	1889.....	45	75	1894.....	32	37

ASBESTOS.

In the production of asbestos in the United States some changes are to be reported for 1894. Practically all the asbestos used in this country hitherto has been imported, the deposits so far discovered, with one exception, being either deficient in quality or so situated that they cannot be profitably worked. The sources of supply remained the same as heretofore until very recently, the Canadian mines furnishing the greater part, over 90% of the total, while a small amount comes from Italy.

Discoveries of extensive deposits of asbestos have been reported in Newfoundland, and the mineral there is said to be of excellent quality, approaching in fineness and length of fiber to the best Canadian. So far, however, no steps have been taken toward working these deposits or even exploring them on any extensive scale.

The exception noted above is found in the mines owned by the Sall Mountain Asbestos Company in White County, Georgia, where a large body of the mineral has been exposed, and sufficient work has been done to prove its existence over a considerable area. Besides mining, this company has erected a plant consisting of two pulverizers, with a capacity of 75 tons per day, and other machinery required for separating and packing the fiber for shipment. In December the company made its first shipments, about 100 tons in all, to Chicago and New York.

At latest accounts some development work is in progress on a promising deposit found near Rockford, in South Dakota, but no definite results have yet been obtained.

The extent of the Canadian asbestos mines, the methods adopted there, and the disposition of the output, were fully treated in The Mineral Industry, Vols. I. and II. Concerning the operation of these mines during the past year Mr. Matthew Penhale furnishes the following information:

Canadian Asbestos.—During 1894 there were no new discoveries of asbestos in Quebec, nor was any addition made to the mines worked in 1893. The Glasgow & Montreal Company's mines were idle, as were also the mines of Ward & Ross, H. W. Johns and Dr. Read, so that the output was not increased. The chief reason was that the companies desired to reduce their stock before mining any large quantities. There has been no change in the mode of mining this ore, but improvements have been made in the manner of dressing and cleaning so as to

reduce the cost, to send the product to market in better shape, and to clean all the lower grades. As the price has gone back almost to the old one it is really necessary to save every fiber of this ore in order to be able to keep the mines open. As at most of them the grade sold now is far better than in the past, and the price for Nos. 2 and 3 is really lower than ever on account of these improvements in dressing; the buyers of these grades get fully one-quarter more fiber than formerly.

The United Company at Black Lake has now the best methods of dressing, having some new machinery, made in England, which will clean the waste into three grades, and make it like wool if necessary. This machinery saves everything, and is the only plant of its kind in this country. King Brothers and some other miners have improved their machinery so as to give good results. Such high prices as formerly are not expected, but the companies are looking for a more steady trade in the present year, as the demand seems to be improving in the United States, where more than one-half of the whole output of Canadian asbestos is shipped every year.

The shipments for 1894 from all the mines in Black Lake and the Thetford district were 7649 tons, against 5539 tons shipped in 1893. This increase of 2110 tons over last year came mostly from the Bell Company, which in working over its rock dumps found stuff almost as good as in the pits; the company then took a large quantity of low-grade stuff from this rubbish, which ran the output up close to 4000 tons, the largest quantity ever taken out in a year by any one company. Other companies did not take out as much as they worked, according to the sales; but if the market should demand 10,000 tons per year those mines could produce that quantity, as all are well supplied with the necessary machinery. The main point with the different managers now is to reduce the cost of production, and the skill shown by the managers of the Bell mine, the United mine, and various others proves this. There were seven mines working in Quebec last year, most of them only in the summer months. Bell's mine worked the whole year, which caused the large output. The shipments for six years past are given below in tons of 2000 lbs.:

SHIPMENTS OF CANADIAN ASBESTOS.

Year.	Tons.	Value	Year.	Tons.	Value.	Year.	Tons.	Value.
1889.....	6,113	$426,554	1891.....	9,279	$1,000,000	1893.....	5,539	$581,595
1890.....	9,860	1,260,240	1892.....	7,431	999,878	1894.....	7,649	.....

The points to which shipments were made in 1894 are given below:

	Tons.		Tons.		Tons.		Tons.
Baldwinville, Mass....	470	Genoa.....	282	Liverpool.....	17	Rotterdam.....	1,001
Cincinnati.....	49	Glasgow.....	111	Marseilles.....	140	Quebec.....	12
Chicago.....	1	Havre.....	205	Montreal, for export..	108	Sherbrooke, for export	125
Erie, Penn.....	964	Hamburg.....	187	New York.....	2,346		
Franklin, Penn.....	62	London.....	1,542	New York, for export.	27	Total.....	7,649

The quantity of asbestos shipped from Danville by the Grand Trunk Railway was small. The output of the Danville mine for 1894 was 1297 tons, which was the largest quantity ever mined there, and probably the same quantity will not

be mined again without considerable outlay for new work. These mines have a very fine quality of asbestos, but most of it is very short, though white and clear, and there is a ready sale for the product. This property is worked by Mr. R. N. Greenshields and others at the present time.

The United Asbestos Company of London is putting up a new factory in Camden, N. J., to use its English patents. This, it is expected, will increase the demand, as the company's mine in Canada will not supply the new factory at the present rate of output. In recent years over 80% of the world's supply has come from Canada. There seems to be some improvement in the industry, and everything will be done at the Quebec mines to bring that result about, both by increasing facilities for mining and improving the methods of treatment.

Australia.—According to Mr. E. Govett many attempts have been made to open up asbestos deposits in Australia, but they have all been attended with failure, owing either to the small quantity found or to the fact that the stuff was of too inferior a quality to be marketable. Asbestos has been found in nearly every serpentine belt in Australia, the longest fiber coming from Gundagai, New South Wales; but shipments have generally been condemned on the ground of insufficient tensile strength. In 1893 another attempt to find superior asbestos at Gundagai was made and failed, while the same result followed operations in Tasmania and at Rockwell, near Broken Hill, in New South Wales. A little actinolite is still sent away from New South Wales, but the quantity is too small for any account to be taken of it. In October, 1893, news reached Melbourne that a deposit of asbestos of unusual length of fiber had been found in Western Australia, but from a description of the material sent it might be gathered that the stuff was too brittle to be of any commercial value. The price paid in Australia for asbestos for paint and boiler-covering purposes varies from £15 to £30 per ton, but sometimes fine Italian asbestos is imported at a cost of £50 per ton. Nearly all the manufactured asbestos used comes from England and Germany.

Fibrous Talc.

Talc occurs near Edwards, in St. Lawrence County, New York, and is found in a narrow belt several miles in length, and about a mile in width. There are several quarries on the line of this belt which formerly belonged to different companies, but in 1893 these companies were all consolidated into a single organization with a capital stock of $3,000,000. This corporation practically controls the whole business in this country. While some discoveries of the mineral have been made elsewhere, the deposit named is the only one from which the fine white fibrous talc, which is in demand in commerce, has so far been obtained. Some explorations have been made outside of the narrow belt upon which all the existing quarries are located, but while the mineral has been found beyond the district named, it has been too much mixed with impurities to be valuable. So far no limit has been found to the deposits in depth; some of the workings are now about 400 ft. below the surface.

The material is ground and prepared for market in mills located near Gouverneur, which are under the control of the Asbestos Pulp Company. The process of manufacture is purely mechanical.

The table below gives the production of fibrous talc in the United States for the five years from 1890 to 1894 inclusive; the statistics for the years previous to 1890 will be found in THE MINERAL INDUSTRY, Vols. I. and II.

PRODUCTION OF FIBROUS TALC IN THE UNITED STATES.

(In tons of 2000 lbs.)

Year.	Quantity.	Value.		Year.	Quantity.	Value.	
		Total.	Per Ton.			Total.	Per Ton.
1889.....	23,746	$244,170	$10.28	1892.....	41,925	$472,485	$11.27
1890.....	41,354	389,186	9.41	1893.....	36,500	337,625	9.25
1891.....	53,054	493,068	9.28	1894.....	39,600	396,000	10.00

The principal use of talc at the present time is for filling and weighting paper. It is specially used in those papers of which wood-pulp forms a considerable part. In wall paper it is largely employed. Outside of the paper trade it is used to a small extent in soap; it also forms the basis of several of the so-called fire-proof paints and plasters. Small quantities are used for adulterating certain products, and in some kinds of paint. In the paper trade its use is continually extending, and the supply is hardly equal to the demand.

SOAPSTONE AND TALC.

The consumption of this mineral is growing steadily and was last year about 50% greater than in 1890. The following table shows the production and imports in the United States for the five years from 1890 to 1894.

SOAPSTONE PRODUCTION, IMPORTS AND CONSUMPTION IN THE UNITED STATES.

(In tons of 2000 lbs.)

Year.	Production.			Imports.			Consumption.	
	Quantity.	Value.		Quantity.	Value.		Quantity.	Value.
		Total.	Per Ton.		Total.	Per Ton.		
1890.....	13,670	$252,309	$18.50	1,044	$11,560	$11.00	14,714	$263,869
1891.....	16,514	243,981	15.00	81	1,121	14.00	16,595	245,102
1892.....	23,208	423,449	18.00	531	5,546	10.00	23,739	428,995
1893.....	20,100	366,825	13.50	1,360	12,825	9.00	21,460	379,650
1894.....	21,044	401,892	19.09	621	6,815	11.00	21,665	408,707

The fact that the output in 1894 did not quite equal that of 1892 was due to the business depression and the smaller demand for soapstone in building and similar work. The price has, however, increased slightly. The imports are very small and are of a special quality used for peculiar purposes. The mineral is found in many places in the United States, but is mined or quarried chiefly in Vermont, New Hampshire, New York, Pennsylvania and North Carolina; the largest quantity comes from New Hampshire. The use is extending rapidly. Its chief employment is in house construction for laundry and bath tubs, hearthstones, grate linings and similar purposes; it is also used for tubs or vats in chemical works. It can be ground into a very fine powder and in that state is used in soap and also in pigments, lubricants, and for dressing skins and leather.

ASPHALTUM.

THE subject of asphaltum was very fully and carefully treated in the article under that title in THE MINERAL INDUSTRY, Vol. II., and its properties, occurrences and uses were described. During 1894, while the use of asphaltum for pavements in the United States increased, no new discoveries have been made, and the production has but very slightly increased. The additional output was entirely from the California mines, those of Utah having remained closed during the year. Every effort is being made to improve the quality and the quantity of the Californian output and with some success, and the present prospect is that considerable additions may be expected to the supply from that source. The Utah output has ceased for a time, chiefly on account of the cost of shipping, which prevents it from competing on the Pacific coast with the Californian output, and in the East with the imported asphaltum.

The production of bituminous rock, which includes asphaltic limestone and sandstone, increased in 1894. The output from California was somewhat less than in 1893, but that from Utah increased slightly, and a very considerable increase came from the Texas deposits, though the Kentucky production was somewhat less. The asphaltic rock from Texas has increased in quantity, and has also a much higher average value than that of previous years.

The following table shows the production of asphaltum and bituminous rock in the United States for the years 1893 and 1894:

PRODUCTION OF ASPHALT AND BITUMINOUS ROCK IN THE UNITED STATES.

(In tons of 2000 lbs.)

States.	1893.						1894.					
	Asphalt.			Bituminous Rock.			Asphalt.			Bituminous Rock.		
	Quantity.	Value.		Quantity.	Value.		Quantity.	Value.		Quantity.	Value.	
		Total.	Per Ton		Total.	Per Ton		Total.	Per Ton		Total.	Per Ton
California	2,290	$44,682	$19.50	22,884	$68,652	$3.00	4,198	$75,654	$18.00	20,370	$81,480	$4.00
Kentucky	.....	.....	.....	6,020	30,100	5.00	.....	.....	.....	5,100	15,350	3.00
Texas	.....	.....	.....	1,000	1,000	1.00	.....	.....	.....	7,200	36,000	5.00
Utah	1,200	24,000	20.00	1,500	15,000	10.00	.....	.....	.....	1,529	15,290	10.00
Total short tons	3,490	$68,682		31,404	$114,752		4,198	$75,654		34,199	$148,120	

The consumption of asphaltum has increased much more rapidly than the production, as will be seen from the second table which we give below. Since 1890 the growth has been nearly 50%, and in spite of the general depression of business the consumption in 1894 showed an important gain.

PRODUCTION, IMPORT AND CONSUMPTION OF ASPHALT AND BITUMINOUS ROCK IN THE UNITED STATES. (IN TONS OF 2240 LBS).

Year.	Production.			Imports.								Exports.		Consumption.
	Asphalt and Bituminous Rock.			From Trinidad. Crude and Refined.			From Europe. Bituminous Rock and Mastic.			Total Imports.				
	Quantity.	Value. Total.	Value. Per Ton.	Quantity.	Value. Total.	Value. Per Ton.	Quantity.	Value. Total.	Value. Per Ton.	Quantity.	Value.	Quantity.	Value	Quantity.
1890	36,465	$190,416	$5.23	54,692	$1,039,148	$19.00	14,370	$129,330	$9.00	69,062	$1,168,478	.....	.....	105,527
1891	40,227	242,264	6.02	71,112	1,422,240	20.00	16,630	149,670	9.00	87,742	1,571,910	398	$4,530	127,571
1892	42,000	262,500	6.25	70,744	1,344,136	19.00	15,400	138,600	9.00	86,144	1,482,736	84	2,513	128,060
1893	31,160	183,434	5.88	69,128	1,451,688	21.00	16,050	144,450	9.00	85,178	1,596,138	378	4,838	116,030
1894	34,283	223,774	6.52	78,112	1,327,902	17.00	21,320	191,880	9.00	99,432	1,519,782	502	9,211	133,233

The following table shows the production of asphaltum and asphaltic rock in the world for a series of years. It will be seen that a large part of the supply is from France, which furnishes very nearly one-third of the total reported.

PRODUCTION OF ASPHALTUM AND ASPHALTIC ROCK. (IN METRIC TONS.)

Year.	Austria.	France.	Germany.	Italy.	Russia.	Spain.	Trinidad.	United States.
1856	143	.....	.....	.....	.....	12	.....	.....
1857	216	.....	.....	.....	.....	.....	.....	.....
1858	1,088	.....	.....	.....	.....	.....	.....	.....
1859	.....	.....	.....	.....	.....	.....	.....	.....
1860	.....	.....	.....	5,300	.....	63	.....	.....
1861	.....	.....	.....	5,500	.....	2,417	.....	.....
1862	.....	.....	520	5,100	.....	1,166	.....	.....
1863	.....	.....	515	5,400	.....	894	.....	.....
1864	.....	.....	595	5,200	.....	3,835	.....	.....
1865	.....	.....	803	5,600	.....	795	.....	.....
1866	.....	.....	675	5,300	.....	2,663	.....	.....
1867	.....	.....	.....	5,500	.....	326	3,787	.....
1868	.....	.....	.....	5,800	.....	1,004	1,549	.....
1869	97	.....	.....	7,100	.....	955	5,380	.....
1870	92	.....	.....	5,600	.....	477	8,950	.....
1871	.....	.....	.....	7,000	.....	.....	4,095	.....
1872	.....	.....	6,017	8,500	.....	.....	12,160	.....
1873	307	156,107	22,678	3,520	.....	.....	7,781	.....
1874	294	137,702	31,147	551	.....	.....	10,070	.....
1875	155	140,696	30,586	1,327	.....	.....	14,970	.....
1876	127	.....	35,988	3,197	.....	5	15,945	.....
1877	79	.....	39,735	7,744	.....	458	13,245	.....
1878	40	.....	47,329	6,979	.....	237	16,040	.....
1879	186	138,431	45,430	12,173	.....	642	23,075	.....
1880	201	144,622	50,072	6,260	.....	584	23,156	403
1881	49	179,257	42,330	9,380	.....	106	26,700	1,815
1882	109	188,064	37,120	8,332	.....	493	30,430	2,722
1883	39	147,337	42,930	6,739	.....	275	40,440	2,722
1884	89	202,307	41,139	17,350	.....	243	38,200	2,722
1885	100	198,385	45,412	13,728	.....	284	35,800	2,722
1886	291	180,742	42,894	17,943	.....	159	36,211	3,176
1887	330	179,207	34,483	18,507	.....	183	43,790	3,630
1888	316	191,718	41,534	20,064	.....	150	52,850	48,811
1889	369	.....	43,496	29,844	.....	387	79,374	46,955
1890	181	233,344	51,144	45,125	140,000	43	80,100	37,061
1891	180	260,626	49,150	28,180	140,394	312	97,725	40,884
1892	78	224,000	53,279	34,580	150,000	668	113,200	42,675
1893	88	222,000	47,238	25,980	155,000	820	93,090	31,655
1894	.....	.....	.....	.....	.....	.....	93,965	35,098

BARYTES.

BARYTES, or heavy spar, as it is sometimes called—more properly barium sulphate—is a common mineral, found in many places. It frequently occurs as a gangue to galena, zinc and other metal-bearing veins, and is also found in veins, or more often in pockets in limestone. The barytes mined and sold comes chiefly from the limestone deposits.

It is found in many places in the United States, but the chief supply is obtained from Virginia and Missouri, where it is found in the largest quantities and most free from impurities. Small amounts are mined in Illinois, New Jersey and other States, and with any increase in demand the production would undoubtedly be developed.

The accompanying table shows the production, imports and approximately the consumption of this mineral in the United States.

PRODUCTION, IMPORT AND CONSUMPTION OF BARYTES IN THE UNITED STATES.

(In tons of 2000 lbs.)

Year.	Production.			Import.			Consumption.	
	Quantity.	Value Per Ton.	Value.	Quantity.	Value Per Ton.	Value.	Quantity.	Value.
1890.....	21,911	$3.95	$86,505	6,362	$4.65	$29,586	28,273	$116,091
1891.....	21,069	5.61	118,363	7,412	3.58	26,546	28,481	144,909
1892.....	28,476	5.00	142,380	4,667	4.88	22,837	33,143	165,217
1893.....	26,632	5.00	133,360	4,459	4.21	18,791	31,091	152,151
1894.....	23,758	4.00	95,032	2,720	5.80	15,826	26,478	110,858

It will be seen that there was a considerable decrease last year, both in the production and in the imports; the consumption was about 12% less than in 1893, and about 20% less than in 1892. The falling off was due entirely to the general depression in business, and not to any special cessation in the demand for this mineral.

The process of preparing barytes for market consists chiefly in sorting out the ore, freeing it from limestone, rock and other impurities, and in crushing and grinding it. Between the coarse crushing and the grinding it is usually boiled in diluted sulphuric acid and then washed to free it from the acid. It is always put upon the market in the finely ground form.

The chief use of this mineral is as a pigment and for that purpose it is ordinarily mixed with white lead. In this country it is not regarded with much favor, being generally considered as an adulterant and as depreciating the value of the paint. In Europe, however, where it has long been used, it is considered as a recognized and often a valuable addition, and in many cases a pigment composed of a mixture of barytes and white lead is considered more serviceable than white lead alone. It has the advantage of being insoluble in acids and alkalies, and will resist influences which disfigure and destroy the pure white-lead paint. The mixture of the two is considered more permanent than the pure lead.

The value, or price, like that of many other articles, was somewhat lower in 1894 than in the previous years, being estimated at about $4 per ton against an average of $5 for several years previously. The barytes imported had a somewhat higher average value that the native mineral, probably because of its more careful preparation and grinding.

Missouri.—According to the State Geological Survey, barytes is produced in Missouri chiefly in Morgan, Jefferson, Miller, St. Francis and Washington Counties, the greater part coming from the last-named district. It is found generally in veins or crevices in limestone and is usually associated with galena. The annual product of Missouri for several years has been not far from 10,000 tons.

New Jersey.—According to the State Geological Survey, the barytes mine near Hopewell, in Mercer County, has been worked at intervals for many years. The old mine-holes are on the northwest side of the Philadelphia & Reading Railroad, about two miles southwest of Hopewell, and one-half mile north of the Glenmore station. The new slopes and pits are near the railroad and northeast of the old-mine locality, and close to the Ege farmhouse. The deposits appear to be associated with the trap rock of the country although the indurated shales (triassic) are near at hand and outcropping. Besides the ore obtained from the deposit (or vein, as known locally), float ore has been dug in considerable quantity south of the mine and east of the old mine-holes and across the railroad line. This mine has been worked almost all of the time since 1890 by G. A. Bush of Jersey City. In 1894 the output amounted in all to 520 tons (of 2000 lbs.).

BAUXITE.

BAUXITE, which is in composition a triple hydrate of aluminum, is a mineral which was comparatively little known until recent years, chiefly because for a long time after its first discovery there was no commercial use for it. The name was given it from the fact that it was first discovered near Baux in France in 1821 by Berthier, the well-known chemist. He attempted to use the mineral from this deposit in the manufacture of alum, but did not at first succeed, owing to the large proportion of iron oxide which it contained. Subsequently, other deposits were found in France, notably the Herault beds or so-called white bauxite, which contains only a very small proportion of iron oxide. Its use, however, did not become important until 1868 or 1869, when M. St. Clair Deville in his experiments in the manufacture of aluminum discovered the value of bauxite as an ore from which that metal could be extracted. Since then its use in the alum manufacture also has extended considerably and a market has been created for this mineral.

United States.—In the United States bauxite was first discovered in Georgia in 1881 and since then has been found in Alabama and Arkansas. At the present time the supply in this country is derived from the Alabama and Georgia deposits, those in Arkansas not having been worked as yet on a commercial scale although their quality is said to be excellent. Discoveries of bauxite have been from time to time reported in several other States, chiefly in North Carolina and South Carolina, but not in workable quantities. A full description of the use of this mineral in alum making will be found in the article on "Alum" in the present volume.

For several years past the native bauxite has been gradually replacing the imported. Domestic production has increased while imports have rapidly decreased. In common with many other industries this suffered in 1894 and the total consumption, which reached 15,516 tons in 1892, and 16,131 tons in 1893, fell in 1894 to 11,761 tons. The Georgia and Alabama bauxites are very similar in quality and occur in the same geological belt. A very full account of these deposits was given in THE MINERAL INDUSTRY, Vol. II., with a number of analyses. The work done during 1894 is described in the article on Alabama and Georgia. The principal variation in quality is found in the proportions of ferric oxide and titanic acid contained in the mineral. It might be added that

as far as examined the Arkansas bauxite contains a much higher proportion of ferric oxide than those of Alabama and Georgia.

The following table shows the production of bauxite in the United States for the years from 1890 to 1894 inclusive, and the imports for the same period:

BAUXITE INDUSTRY OF THE UNITED STATES.
(In tons of 2240 lbs.)

Year.	Production.				Imports.		Consumption.	
	Alabama.	Georgia.	Total.					
1890	.....	1,850	1,850	$9,250	12,278	$46,137	14,128	$55,387
1891	600	3,300	3,900	19,500	8,021	46,252	11,921	65,752
1892	4,900	4,900	9,800	49,000	5,716	57,948	15,516	106,948
1893	7,063	3,965	11,028	55,205	5,103	28,217	16,131	83,422
1894	8,687	2,045	10,732	42,928	1,028	6,661	11,760	49,589

France.—France, where bauxite was first discovered, still produces the largest quantity. Its principal use, as in the United States, is as an ore of aluminum and in the manufacture of alum and sulphate of alumina. A considerable quantity is exported from France at the present time, some of it coming to the United States, but a much larger part going to Germany and to Switzerland. In the last named country a considerable quantity is used by the Neuhausen Company in its extensive aluminum works. Three varieties of the mineral are known, the white bauxite of the Herault, the pale bauxite of Baux, which is also found at several other departments in the south of France—the Bouches du Rhone, the Var and Alpes Maritimes—and the red bauxite. In general it may be said that the white bauxite is comparatively free from ferric oxide but contains a higher percentage of silica, while the red bauxite is lower in silica and contains more of the iron oxide.

Other Countries.—Bauxite is also found in Germany in considerable deposits, but not of as good quality as the French. In a few exceptional cases the percentage of alumina is high, but most German bauxites are lower in alumina than the French and they are high in silica and iron. In Germany the mineral was for a long time called wocheinite, from the fact that it was discovered near the village of Wochein. Other localities where it is found are Langsdorff, Steinheim, Hardmar and Vogelsberg. The Vogelsberg ore is very pure but comparatively limited in quantity.

Bauxite is also found in Austria and Italy, but has not been worked there to any considerable extent. The largest deposits known to exist in Europe, next to the French beds, are in Ireland. The mineral here is of an excellent quality, carrying somewhat more silica than the French bauxite and is free from titanic acid and with only a moderate quantity of iron oxide. A considerable quantity of it is used in the alum manufacture in Great Britain, and a new company, recently organized, proposes to use it in making aluminum.

So far the greater quantity of bauxite produced has been used in making alum; the aluminum industry absorbs only comparatively a small quantity. The prospect is that the last named demand will increase and it may eventually become more important as far as the consumption of bauxite is concerned than any other.

BORAX.

Of the borax industry in the United States in 1894 but little is to be said beyond what is shown by the statistics. The industry showed a course differing from that of many others during the year; the production, which in 1893 decreased by over one-fourth from the average of several preceding years, not only regained this loss in 1894 but showed an increase over 1892, the total product being the highest for any year on record. The source of production has continued to be the great borax lakes or marshes and the mines of southeastern California and southern Nevada, and while some new discoveries were reported, no developments of any importance were made, the output being drawn from the old deposits.

The following table shows the production of the United States from 1890 to 1894, inclusive. Statistics for the years previous to 1890 will be found in The Mineral Industry, Vols. I. and II.:

BORAX INDUSTRY IN THE UNITED STATES.

Year.	Production.					Imports.	
	California.	Nevada.	Total.	Av. Wholesale Price in N.Y.	Value.		
	Pounds.	Pounds.	Pounds.	Cents.	Dollars.	Pounds.	Dollars.
1890.....	6,402,034	5,487,794	11,889,828	7½	$891,737	8,670,140	$44,242
1891.....	8,533,337	3,296,663	11,830,000	7½	887,250	760,232	51,131
1892.....	11,050,495	1,487,701	12,538,166	7½	940,365	705,635	39,850
1893.....	7,199,000	1,199,438	9,199,000	7½	689,925	*a*1,336,639	51,724
1894.....	11,540,099	1,600,495	13,140,594	7	919,842	.....	.....

(*a*) For the first six months only.

No changes in methods of working are reported, and there is little or nothing to be added to the statements given in the previous volumes of The Mineral Industry.

The increase in production was accompanied with a slight decrease in price. The average wholesale price in New York for the four years, 1890 to 1893 inclusive, remained at the same figure, 7½c. Last year, however, the average was reduced to 7c. per lb., remaining at that point throughout the year. The market is practically controlled by a single corporation, the Pacific Coast Borax Company, which accounts for the absence of fluctuations. An increase in demand

can easily be met by an increase in output, as the California and Nevada deposits are not worked by any means to their full extent, and, as we have mentioned before, new deposits are known, the production of which can be brought into market when required.

The chief sources of supply outside of the United States are in Tuscany in Italy. Exports from these deposits supply the market in England and nearly all the countries of Europe.

In Germany, however, considerable quantities of stassfurtite are obtained from the salt mines at Stassfurt, where the mineral is found in small masses embedded in the salt. There is no other source of supply in Europe outside of these mines and the Italian borax springs.

In Asia, the deposits at Suzurlu in Asia Minor are extensive. They were opened about 25 years ago, and now export about 8000 tons yearly of calcium borate. In India borax has been mined for many years on the northern frontier of the country, the work, however, being limited on account of the difficulty of transportation across the Himalayas. Some borax is also brought into India from Thibet, where the conditions of its occurrence and mining are very much the same as in the first-named country.

In South America ulexite is obtained from some localities in Chile. The borate is taken out from marshes or dried lake bottoms in very much the same way as in California and Nevada. Some borate is also found in the Argentine Republic. Shipments from the last named deposits are made chiefly to France and Germany.

It is worthy of note, that with the exception of the small amount taken from the Stassfurt salt mines, the only deep mining for borax known is in the Calico district in California, where the borax is mined from a fissure vein and the workings have extended to a considerable depth. In all other portions of the world the mineral is obtained from saline springs or marshes formed by such springs.

BROMINE.

BROMINE occurs extensively in nature but never in a free form, being found always in combination with other elements, chiefly as a bromide. Its manufacture is an industry of some importance, as will be seen by the figures of production given below. It is found in sea water and also in the brine from certain salt wells in Germany and the United States, but the commercial product comes from the salt wells entirely. In the United States bromine is obtained from the mother liquor of a number of wells in the salt belt which extends through western Pennsylvania, eastern Ohio and West Virginia, and also from some salt wells in Midland County, Michigan. In Germany the bromine is recovered as a by-product in the salt works at Stassfurt and Leopoldschall. The principal points of production in the United States are now in Ohio and West Virginia. The manufacture of bromine was first established at Freeport, Penn., in 1846, by Dr. David Alter, and is still continued at several points in the State, although the original works are not now in operation. The manufacture in Ohio was begun in 1871, but in Michigan it was not commenced until 1885. The following table gives the production in the United States for five years past :

PRODUCTION OF BROMINE IN THE UNITED STATES.

Year.	Michigan.	Ohio.	Pennsylvania.	West Virginia.	Total.	
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Value.
1890....	59,696	101,813	108,154	118,183	387,847	$104,719
1991....	47,320	121,681	85,832	113,953	368,786	73,757
1892....	43,864	135,683	92,978	104,142	376,667	64,034
1893....	42,568	113,575	111,403	80,852	348,399	87,100
1894....	29,116	146,501	100,623	103,304	379,444	98,655

The United States is the largest producer next to Germany. The works at Stassfurt and Leopoldschall, above referred to, manufacture about 300,000 kilo s, or 660,000 lbs. yearly, which, added to the United States production, would make the total output about 1,040,000 lbs. in 1894.

The principal uses of bromine are found in the preparation of potassium bro mide and other bromides, though small quantities are used also in the manufacture of colors and as a disinfectant. Experiments have been made at various times with bromine instead of chlorine in the treatment of gold ores, and have met

with much success. It is possible that an increase in the demand will come from this source, although no mills are as yet employing bromine on an extensive scale, and its cost is a drawback to its increased use.

It will be noticed that, notwithstanding the general depression in business, the production in the United States last year showed a considerable increase over that of 1893, and was in fact a little greater than that of 1892. The increase reported was entirely from the producers in Ohio and West Virginia ; those in Pennsylvania and Michigan showed a decrease in their output. The processes of manufacture were fully described in THE MINERAL INDUSTRY, Vol. II., and no changes of importance were made during 1894.

The price of the article varied very little during the year. The agreement between the German and American producers, which was made in the latter part of 1892, has continued in operation and there has been none of the sharp competition which marked the business prior to that date. Prices have been fairly well maintained, and there is no present indication of a reduction or of a break in the agreement. The average price for the year was 26c. per lb.

CEMENT.

THE general properties of cements have been so well discussed in the articles on that subject in Vols. I. and II. of THE MINERAL INDUSTRY that it is unnecessary to add more on that subject.

During 1894 there were three works in the United States destroyed by fire; six works discontinued operations, and a number of new works expect to begin manufacturing in 1895.

During 1894 ten Schmidt kilns, with a capacity of 80 barrels per day each, were erected by the Coplay Cement Company for the manufacture of Portland cement. It is interesting to note that while other companies are adopting the rotary furnaces, this pioneer in the American manufacture has adopted the kiln; the reason is said to be because the rotary furnaces are compelled to use petroleum as fuel, and the price of this is uncertain, being controlled practically by one company. The kilns at Coplay use cheap anthracite slack.

Among new patents taken out may be noticed attempts to render the clinker more fusible by the addition of soda and thus avoid the use of high temperatures. Compressing the cement is the purpose of another. At the present time the object is to produce a finely ground cement cheaply according to an approved formula. The Askham pneumatic separator is a decided improvement in this direction. The loose roller mills seem to have the preference among grinders; the Griffin mill has, however, been introduced into several German works.

The following table gives an interesting comparison of Portland cements from the various producing countries, according to the French, German and English formulas of manufacture, which are as follows:

$$\text{French formula} = \frac{SiO_2 + Al_2O_3 + Fe_2O_3}{CaO, MgO} = a.$$

$$\text{German formula} = \frac{CaO, MgO}{SiO_2 + Al_2O_3 + Fe_2O_3} = b.$$

$$\text{English formula} = \frac{CaO + MgO}{SiO_2 + Al_2O_3} = c.$$

The impurities which cause the rejection of Portland cement are: MgO exceeding 1%; CO_2 exceeding 1½%; SO_3 exceeding 1½%; CaO not in combination.

COMPARISON OF PORTLAND CEMENTS. (*a*)

Country.	SiO_2. %	Al_2O_3. %	Fe_2O_3. %	CaO, MgO. %	*a*	*b*	*c*
English	22.70	8.10	3.30	61.50	.554	1.80	2.00
German	22.50	7.60	3.00	64.40	.514	1.94	2.14
Belgian	24.60	6.40	2.80	62.80	.538	1.86	2.03
Russian	22.20	7.20	3.40	64.20	.500	1.96	2.17
French	23.60	7.50	2.90	63.20	.530	1.86	2.03
United States	21.24	7.41	3.22	63.26	.504	1.98	2.20
Sweden	21.25	6.47	3.43	65.41	.461	2.09	2.36

(*a*) Compiled from *Le Genie Civil*, Paris.

Cement is used alone, or in mortar and concrete in heavy foundation work, under or above water; as sidewalks, floors, lining for reservoirs and roofs; in foundations for asphalt, macadam or brick paving; in tile and marble floors, and for stucco work and house plastering; in mortars for brick or heavy stone masonry; in linings for iron water pipes and conduits and in drain tile; in bath tubs, water troughs and pipes made of a wire network frame surrounded by cement; statues, columns with capitals, balusters, steps, sewer conduits in sections, window frames, tiles for floor and wainscot (made under pressure), and slabs in imitation of marble or slate. Silicated cement slabs and drain pipes have been used for the past 20 years with great satisfaction and yet are little known.

Estimating the world's production of cement at 40,000,000 barrels yearly, the United States produces about one-fifth of the whole and consumes more than any other country. Notwithstanding the duty of 32c. per barrel, foreign brands compete successfully in our home market, owing partly to a preference many buyers have for foreign cement. The price has been lowered 18% for natural hydraulic brands and 6% for Portland within a year. Our American manufacturers are not fully alive to the demands of the times for better practice.

Natural Hydraulic Cement.—The statistics of production given in the following table are from reports made by all the producers for use in this work. Prices have varied considerably even in adjoining localities, and the average has fallen about 18% since 1893.

PRODUCTION OF NATURAL HYDRAULIC CEMENT IN THE UNITED STATES.
(In barrels of 300 lbs.)

States.	1893.			1894.		
	Barrels.	Value at Works.		Barrels.	Value at Works.	
		Total.	Per Bbl.		Total.	Per Bbl.
Georgia	9,057	$7,667	$0.84	.....	.....	.....
Illinois	265,000	90,000	.34	220,000	$75,000	$0.34
Indiana	300,646	100,012	.33	279,132	96,148	.33
Kansas	225,000	132,500	.60	171,000	95,750	.56
Kentucky	1,449,704	862,680	.59	2,225,000	1,057,500	.47
Maryland	285,000	160,250	.56	272,250	131,125	.48
Minnesota	114,750	70,750	.67	105,506	59,183	.56
New York, Ulster County	2,738,884	2,191,107	.80	2,659,601	1,755,337	.66
New York, Onondaga County	176,308	106,721	.60	220,698	105,975	.48
New York, Schoharie County	30,000	25,000	.83	32,735	25,830	.78
New York, Erie County	675,000	496,250	.73	587,842	409,173	.69
Ohio	40,185	38,801	.96	49,066	43,910	.89
Pennsylvania	567,000	406,000	.60	511,439	292,482	.57
Virginia	25,700	21,960	.90	7,000	5,800	.86
West Virginia	17,450	12,460	.70	32,000	19,000	.60
Wisconsin	526,266	288,800	.55	521,157	225,194	.43
Total barrels	7,445,950	$5,010,958	$0.67	7,894,426	$4,397,407	$0.55
Total metric tons	913,677	.....	.....	1,074,179	.....	.....

The center of the natural hydraulic cement industry is at Rosendale, Ulster County, New York, where it was first established in 1823, when the hydraulic property of the magnesian limestone there found was discovered. The composition of the limestone and the other information concerning this district is kindly furnished by Mr. Hiram Snyder.

TYPICAL ANALYSIS OF "ROSENDALE" HYDRAULIC LIMESTONE.

SiO_2	22.14	$MgCO_3$	23.92
Fe_2O_3, Al_2O_3	3.80	K_2O, Na_2O	Traces
MnO	.88	Organic matter	.83
$CaSO_4$	3.94		
$CaCO_3$	44.34	Total	99.85

This rock is hard and difficult to quarry ; it is crushed in a Gates type of rock breaker ; then it is ground in millstones 4 ft. 6 in. in diameter, having a capacity of 200 barrels per day of 10 hours. It is packed in paper-lined barrels, containing 300 lbs. of cement. The barrel weighs 17 lbs. The manufacturing season opens about the middle of March and continues about nine months.

The following table represents the production of the Rosendale district since 1848, which is as far back as records are available. The manufacture, which began about 1827, was on a small scale only up to 1848.

PRODUCTION OF NATURAL HYDRAULIC CEMENT IN THE ROSENDALE DISTRICT.

Year.	Barrels.	Price.	Total Value.	Year.	Barrels.	Price.	Total Value.
1848	190,000	$1.37	$260,300	1873	1,355,000	1.75	2,371,250
1849	210,000	1.35	283,500	1874	1,343,000	1.40	1,880,200
1850	240,000	1.35	324,000	1875	1,148,000	1.20	1,377,600
1851	310,000	1.27	395,250	1876	1,085,000	1.20	1,302,000
1852	362,000	1.25	452,500	1877	991,000	1.10	1,090,100
1853	456,000	1.20	547,200	1878	1,089,000	.90	980,100
1854	474,000	1.27	604,350	1879	1,376,000	.97	1,341,600
1855	485,000	1.07	518,950	1880	1,432,000	1.05	1,503,600
1856	510,000	1.05	535,500	1881	1,500,000	1.20	1,800,000
1857	610,000	1.20	732,000	1882	1,663,000	1.07	1,878,725
1858	740,000	1.05	707,000	1883	1,576,000	1.07	1,694,200
1859	670,000	.87	586,250	1884	1,656,000	.97	1,614,600
1860	740,000	1.00	740,000	1885	1,766,000	.95	1,589,400
1861	440,000	.90	396,000	1886	2,054,000	.90	1,848,600
1862	530,000	.90	477,000	1887	2,339,000	.92	2,133,575
1863	530,000	1.20	696,000	1888	2,262,984	.90	2,036,686
1864	580,000	1.55	899,000	1889	2,507,000	.87	2,193,625
1865	590,000	1.65	1,138,500	1890	2,683,615	.82	2,213,982
1866	905,000	1.75	1,583,750	1891	2,815,010	.80	2,251,908
1867	849,000	1.70	1,443,300	1892	2,833,107	.80	2,266,485
1868	957,000	1.80	1,722,600	1893	2,738,884	.83	2,273,274
1869	1,136,000	2.00	2,272,000	1894	2,659,601	.82	2,180,873
1870	1,170,000	1.95	2,281,500				
1871	1,227,000	1.75	2,147,250	Total	57,169,201	.....	$63,782,083
1872	1,385,000	1.60	2,216,000				

Portland Cement.—In the Eastern States there have been many local variations, but generally a growth in production, somewhat unequally distributed.

In California the production is steady and prices realized are fair, though freights are high. The imports of foreign cement into San Francisco for 1894 were as follows, in barrels of 400 lbs. each :

Imported from	Barrels.	Declared Value.	
		Total.	Per Bbl.
Belgium	71,949	$90,017	$1.25
United Kingdom	216,451	274,871	1.27
Total, 1894	288,400	$364,888	$1.26
Total, 1893	264,110	.....	.....

The shipments by rail to San Francisco from the East in 1894 were 5071 barrels of cement and plaster. The market price of Portland was $2 to $2.50, according to brand, and the market good though somewhat overstocked.

In the table below, which gives the production for two years, the quantities have been reduced to barrels of 300 lbs. for comparison, though the foreign standard is 400 lbs. per barrel.

PRODUCTION OF PORTLAND CEMENT IN THE UNITED STATES.

(In barrels of 300 lbs.)

States.	1893. (a)			1894.		
	Barrels.	Value at Works.		Barrels.	Value at Works.	
		Total.	Per Bbl.		Total.	Per Bbl.
California	10,000	$23,500	$2.35	8,613	$20,400	$2.35
Colorado	15,000	30,000	2.00	12,000	28,000	2.33
New Jersey	65,578	98,481	1 50	97,532	136,684	1.40
New York	103,174	176,345	1.71	72,776	130,752	1.79
Ohio	45,933	81,806	1.78	106,176	157,072	1.48
Pennsylvania	372,504	532,741	1.43	360,999	466,386	1.20
South Dakota	41,800	69,300	1.60	55,100	91,350	1.65
Texas	20,000	40,000	2.00	25,000	50,000	2.00
Total barrels	673,989	$1,052,173	$1.56	738,196	$1,080,644	$1.47
Total metric tons	91,715	.....	.....	100,352	.....	.....

(a) Statistics for the year 1893 as published in THE MINERAL INDUSTRY, Vol. II., have been revised and corrected by information which was not then available.

The sources from which the foreign supply is drawn are shown in the following table, compiled from the official reports for the fiscal years ending June 30:

CEMENT IMPORTED FROM BELGIUM, ENGLAND AND GERMANY.

(In barrels of 400 lbs.)

Year.	Belgium.			England.			Germany.		
	Barrels.	Value.		Barrels.	Value.		Barrels.	Value.	
		Total.	Per Bbl.		Total.	Per Bbl.		Total.	Per Bbl.
1890	259,834	$208,921	$0.80	1,073,768	$1,169,902	$1.09	723,487	$774,591	$1.07
1891	533,920	687,520	1.28	1,336,176	1,983,766	1.48	922,007	1,328,617	1.44
1892	475,903	614,600	1.43	1,127,618	1,675,197	1.48	1,073,768	1,549,821	1.44
1893	386,357	499.758	1.29	1,115,699	1,481,923	1.32	1,270,193	1,724,756	1.36
1894	496,806	609,151	1.23	1,006.365	1,276,113	1.26	992,149	1,325,059	1.34

The stock on hand in first hands on Jan. 1, 1894, at New York, was 65,000 barrels. On Jan. 1, 1895, it was 45,000 barrels.

The market prices per barrel of foreign brands ranged about as follows: Belgian, $1.65; English, $1.80@$1.90; German, $2@$2.30. The prices of European cements declined in 1894.

The following table is a brief summary of the American production and estimated consumption. Our export trade is principally with South America. About one-sixteenth of the total exports are of American cement.

CEMENT PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION IN THE UNITED STATES.

(In barrels of 300 lbs.)

Year.	Production.				Imports.		Exports.		Consumption.	
	Natural Hydraulic.	Portland.	Total Barrels.	Value.	Barrels.	Value.	Barrels	Value.	Barrels.	Value.
1890.....	.....	.....	8,000,000	$6,000,000	3,422,835	$3,175,159	98,663	$166,517	11,324,172	$9,008,642
1891.....	.....	.....	8,222,792	6,680,951	3,988,315	4,411,330	97,124	147,668	12,113,983	10,944,613
1892.....	8,211,181	547,440	8,758,621	7,152,750	3,254,273	3,378,331	107,894	169,538	11,905,000	10,361,543
1893.....	7,445,950	673,989	8,119,939	6,063,131	3,565,932	3,470,169	112,520	174,663	11,573,451	9,358,737
1894.....	7,895,259	738,196	8,633,455	5,478,051	3,517,476	3,396,729	120,966	180,881	12,029,965	8,693,901

We give below some notes of the production in other countries.

Belgium.—This country ships large quantities of cement to the United States. Some of the grades approach very nearly our Rosendale cement, though better grades are offered on the market, generally at a lower price than the other foreign makes.

Denmark.—Works have recently been established in Jutland, at the seaport town of Aalborg, which are competitors in the German market by reason of cheap transportation facilities, although Germany formerly controlled the trade in Denmark.

France.—The commercial manufacture of Portland cement in France began about 1830, and has been a prosperous industry ever since. The four producing localities have the following annual capacity.

PORTLAND CEMENT IN FRANCE.

Producing Localities.	Metric Tons.	400 lb. Barrels.	No. of Kilns.
Meyasse and Melas.....	30,000	165,300	16
Cruas and Clére.....	65,000	358,150	18
Teil.....	75,000	413,250	21
Lefarge-du-Teil.....	265,000	1,460,150	45
Total.....	435,000	2,396,850	100

The production of France is sufficient for its own consumption, and it exports considerable quantities to the American markets. The imports from England amount to not over 3000 tons a year at present, having decreased from 13,220 tons in 1888.

Germany.—Though in this country the manufacture of cement was begun later than in France and England, Germany is now a formidable competitor in the trade. Realizing the importance of quality in cement, the German makers sought to establish standard grades by issuing rules compiled by the Prussian Minister of Public Works, specifying what tests should be applied to determine the quality of the product. These rules, which were published in November, 1878, were amended in July, 1887, by recommendation of the Association of German Cement Manufacturers, and were the only recognized standard until June, 1885, when the American Society of Civil Engineers compiled and recommended a uniform system of tests.

The output having increased enormously, the price declined to a non-profitable figure; the Eastern German manufacturers combined and limited the output with the result of greatly increasing the profits of the business. As stated by *The*

Cement Review, in the Groschowitz district dividends increased from 7½% to 10½% in 1894; in the Grundiraun district from 4½% to 6½%; Giesel district from 2% to 4½%; Oberschlesische district from 2½% to 6%; the Alsen Company from 8% to 10%.

The annual production of Germany is now about 12,000,000 barrels, 11,000,000 barrels being produced by members of the association. The annual export is now about 2,400,000 barrels. In 1893 the exports were distributed as follows: To the United States, 957,269 barrels; Holland, 393,072 barrels; Austria-Hungary, 211,215 barrels; other countries, 774,089 barrels. It is thus seen that the United States took in that year nearly 40% of the total exports. The German manufacturers are quick to adopt improvements, and there is probably more American machinery found in German cement works than in our own works.

Russia.—The cement works of this country are located near Moscow and along the Baltic and Black Seas, where they have displaced the German and Swedish cement from the markets. The annual imports of cement into Russia amount to about 600,000 barrels, and as this has been quite constant for a number of years, the steady increase of home production indicates a corresponding increase in consumption.

Sweden.—The cement works at the seaport town of Malmö have been in operation over 20 years with a nearly steady increase in production as follows:

CEMENT PRODUCTION IN SWEDEN.

Year.	Value.	Year.	Value.	Year.	Value.	Year.	Value.
1874	$34,922	1879	$97,649	1884	$198,036	1889	.....
1875	59,669	1880	130,311	1885	162,247	1890	$477,729
1876	93,257	1881	134,700	1886	162,495	1891	487,858
1877	108,000	1882	157,909	1887	183,974	1892	581,188
1878	108,000	1883	203,477	1888	304,620	1893	507,668

Up to 1891 there was but one producer. A great part of the product goes to Russia, which has imported from Sweden the following number of barrels:

SWEDISH EXPORTS TO RUSSIA.

Year.	Barrels.	Year.	Barrels.	Year.	Barrels.	Year.	Barrels.
1874	3,214	1879	20,321	1884	10,342	1889	10,000
1875	7,678	1880	23,005	1885	19,440	1890	9,900
1876	10,115	1881	14,623	1886	11,750	1891	.....
1877	11,864	1882	13,911	1887	20,000	1892	.....
1878	17,623	1883	21,395	1888	10,400	1893	.....

In quality the Swedish cement is light in weight, because of its fineness (7% residue on a 180-mesh sieve), having a specific gravity of 3.06 to 3.14, or about 194 lbs. per cu. ft., and 92 to 105 lbs. per imperial stroked bushel. The tensile strength of briquettes made with it is high, and the quality is said to be very uniform.

United Kingdom.—English cement has in recent years been displaced by other brands in Russia, Sweden, Denmark, Germany, and largely in France; in South

America, South Africa and Australasia there is practically no home competition. The following table will show the growth of the export trade:

EXPORTS OF CEMENT FROM ENGLAND.
(In barrels of 400 lbs.)

Year.	Barrels.	Year.	Barrels.	Year.	Barrels.
1840.....	13,222	1860.....	443,369	1880.....	1,553,944
1845.....	66,089	1865.....	632,085	1885.....	2,060,212
1850.....	67,321	1870.....	842,741	1890.....	3,514,264
1855.....	197,086	1875.....	1,377,001	1894.....	2,384,629

The English mills are being generally remodeled, introducing the new large-capacity grinding machines, pneumatic separators, etc. The capital invested in the industry in England is estimated at £20,000,000. There are no statistics compiled which give the English production.

Stamp Sand for Cement Mortar.

By Edgar Kidwell.

During the year 1894 a series of cement tests were made under my direction by Mr. Frederick W. Ridley. It is a matter of common belief in the West that stamp sand makes a stronger mortar than the ordinary river or bank sand obtainable, and it was decided to include such tests as would be necessary to show the truth or error in this belief. That the results might be easily compared with other regular cement tests already published, it was decided to use in the work only stamp sand and the standard quartz sand recommended by the American Society of Civil Engineers. The standard sand was sifted as recommended, and all was rejected which passed through 900 meshes per sq. in., or failed to pass through 400 meshes. Wire in the 900-mesh sieve was No. 31, and in the 400-mesh No. 28, Stubb's gauge. The stamp sand was taken directly from the dump of the Franklin stamp mill, and was neither washed nor sifted, as the local custom is not to clean the sand in any way. The Franklin mine works on a bed of melaphyr, locally called an amygdaloid, and the sand is very coarse, variable in size, and contains some dirt.

All the tensile and compressive tests were made on a 2000-lb. Olsen testing machine, the load being applied through a screw worked by hand, and put on as nearly as possible at the rate of 400 lbs. per minute. The tension briquettes were of the standard shape adopted by the American Society of Civil Engineers. Compression briquettes were 1 in. cubes, and cross-breaking specimens were 1 by 1 by 13 in., resting on bearings 12 in. apart.

The cements tested were: Buffalo, made by Buffalo, N. Y., Cement Company; Akron, made by Cummings Akron Company, Akron, N. Y.; London Portland, made by Brooks, Shookridge & Co., Grays, Essex, Eng.; Louisville Anchor brand, made by the Union Cement & Lime Company, Falls Mills City, Louisville, Ky.; Rosendale, made by Newark & Rosendale Lime and Cement Company, New York.

The accompanying table gives all the essential data of the tests, and shows conclusively the superior strength of the mortar made from stamp sand.

TABLE I—NEAT CEMENT.

Name of Cement.	Fineness. Cement rejected by Sieves. No. Meshes per sq. in.			Record of 7 Day Tests.																		Record of 28 Day Tests.															
				Mixing.			Testing.		Tensile Strength in lbs. per sq. in.							Comp. Str. in lbs. per sq. in.			Cross-Break'g		Mixing.		Testing.		Tensile Strength in lbs. per sq. in.							Comp. Str. in lbs. per sq. in.			Cross-breaking.	
									No. of Briquette.							No. of Cube.									No. of Briquette.							No. of Cube.				
	2500	6400	10,000	% Water used.	Temp. of Water in F°.	Temp. of Air.	Temp. of Air.	Temperature of Immersion Water.	1	2	3	4	5	6	Average.	1	2	Average.	Load on Centre.	Modulus of Rupture.	Temp. of Water in F°.	Temp. of Air.	Temp. of Air.	Temp of Immer. Water.	1	2	3	4	5	6	Average.	1	2	Average.	Load on C'tre	Modulus of Rupture.
Portland	4%	13%	16%	29 %	65 °	73 °	71 °	63.9°	353	357	457	376	350	320	368.8	1442	1525	1483.5	44	792	67.5°	78 °	70 °	65 °	457	498	500	507	470	...	506.4	2000	2000	.....	64	1152
Buffalo	16%	24%	26%	33 %	67 °	73 °	70.5°	64.5°	114	98	110	138	103	83	107.6	656	727	691.5	14	252	67 °	73 °	65 °	64.5°	260	293	285	264	220	240	260.3	1247	1394	1320.5	40	720
Akron	5%	15%	18%	35.5%	62 °	68 °	70 °	64 °	40	44	60	48	35	...	45.4	310	346	328	17	306	66.5°	69 °	73 °	63.5°	161	146	160	163	146	169	137.5	610	648	629	25	450
Louisville	16%	25%	28%	38 %	67.5°	74 °	61 °	64.2°	86	70	85	86	74	87	81.3	433	373	403	....	....	70 °	75 °	71 °	62.8°	130	144	124	132	139	114	130.5	620	619	619.5	2	36
Rosendale	6%	8%	11%	38 %	65.5°	73 °	73 °	63 °	47	42	40	46	45	47	44.5	183	194	188.5	....	....	65.5°	73 °	69 °	63.7°	129	110	99	132	108	70	108	216	538	377	11	198

TABLE II—1 PART CEMENT TO 1 OF STANDARD SAND.

Portland	....	....	....	20.6%	70 °	77 °	67 °	63.9°	241	217	217	246	141	220	213.6	1178	1127	1152.5	....	....	70 °	78 °	70.5°	65 °	307	299	298	324	327	312	311	1980	....	.....	..	....
Buffalo	....	....	....	21 %	68 °	73 °	70.5°	64.5°	56	43	55	50	46	30	46.6	300	260	280	....	....	70 °	75 °	69 °	64.5°	125	130	126	138	134	133	131	615	450	532.5	..	....
Akron	....	....	....	19 %	66.5°	70 °	71.5°	64 °	56	46	48	35	46	31	47	161	153	157	....	....	66 °	70 °	75 °	63.5°	88	65	72	56	78	50	69.6	424	326	375	..	....
Louisville	....	....	....	26 %	69 °	75 °	61 °	64.2°	36	38	45	48	45	10	37	254	226	240	....	....	67 5°	75 °	61 °	62.8°	66	69	63	68	73	72	68.5	250	221	235.5	..	....
Rosendale	....	....	....	23 %	65 °	71 °	73 °	63 °	19	18	22	25	15	15	15.6	90	126	108	....	....	65 °	71 °	69 °	63.7°	84	75	98	68	100	84	84.8	260	268	264	..	....

TABLE III—1 PART CEMENT TO 1 OF STAMP SAND.

Portland	....	....	....	14.5%	72 °	74.5°	71 °	63.9°	260	265	123	235	280	168	223.5	1175	2000	1587.5	....	....	65 °	71 °	71 °	65 °	378	400	425	442	404	442	415	2000	....	.....	..	....
Buffalo	....	....	....	20 %	68 °	74 °	70.5°	64.5°	49	55	59	56	57	57	55.5	315	329	322	....	....	69 °	76 °	68 °	64.5°	179	183	144	151	160	196	167.1	1078	1157	1117.5	..	....
Akron	....	....	....	18.5%	67 °	68 °	75 °	64 °	55	30	40	47	45	54	45.1	238	207	222.5	....	....	65 °	67 °	74 °	63.5°	78	97	69	90	74	86	82.3	441	496	468.5	..	....
Louisville	....	....	....	22 %	68 °	72 °	72 °	64.2°	44	42	38	42	...	...	.....	270	200	235	....	....	67.5°	73.5°	63 °	62.8°	110	109	101	98	103	96	102.8	500	439	469.5	..	....
Rosendale	....	....	....	21 %	65 °	70.5°	71.5°	63 °	15	5	18	18	18	14	14.6	159	110	134.5	....	....	65 °	70.5°	75 °	63.7°	82	72	55	76	75	...	72	356	300	325	..	....

TABLE IV—1 PART CEMENT TO 3 OF STANDARD SAND.

Portland	....	....	....	19.2%	67.5°	78 °	70 °	65 °	46	60	40	48	53	60	51.1	420	....	.....	....	....	71.5°	78 °	70 °	65 °	122	85	90	104	123	111	105.8	420	....	.....	..	....
Buffalo	....	....	....	18.7%	68 °	75 °	70 °	64.5°	18	18	19	15	16	17	17.1	39	60	49.5	....	....	67.5°	77 °	69 °	64.5°	22	20	25	19	25	19	21.6	100	85	92.5	..	....
Akron	....	....	....	17 %	67 °	71 °	74 °	64 °	13	10	15	19	18	16	15.1	44	40	42	....	....	66.5°	70 °	75 °	63.5°	24	21	27	16	25	18	21.8	75	87	81	..	....
Louisville	....	....	....	22 %	68 °	70 °	70 °	64.2°	7	5	4	7	...	...	5.75	46	30	38	....	....	67 °	74 °	61 °	62.8°	18	17	16	11	14	17	15.3	48	56	52	..	....
Rosendale	....	....	....	20.5%	65.5°	70 °	71 °	63 °	...	...	...	...	...	...	.....	20	23	21.5	....	....	67 °	74 °	73 °	63.7°	...	...	...	...	...	...	.....	35	52	43.5	..	..

TABLE V—1 PART CEMENT TO 3 OF STAMP SAND.

Portland	....	....	...	11.25%	64.5°	72 °	72 °	63.9°	116	120	140	140	135	...	132.2	504	509	506.5	....	....	65 °	71 °	71 °	65 °	343	377	276	294	291	309	315	1419	1494	1456.5	..	....
Buffalo	....	....	...	13. 3%	69 °	70.5°	70.5°	64.5°	37	35	30	28	25	43	33	188	112	150	....	....	72 °	76.5°	68 °	64.5°	62	67	76	69	70	63	67.8	582	423	502.5	..	....
Akron	....	....	...	12 %	66.5°	73.5°	72 °	64 °	22	22	26	27	23	24	24	157	170	163.5	....	....	65 °	70.5°	73 °	63.5°	37	36	31	40	29	34	34.5	267	238	252.5	..	....
Louisville	....	....	...	15 %	68 °	71 °	71.5°	64.2°	22	7	10	14	10	7	14	113	70	91.5	....	....	69 °	76 °	64 °	62.8°	34	54	31	36	30	20	34.1	241	120	180.5	..	...
Rosendale	....	...	...	15 %	66 °	70.5°	72 °	63 °	11	8	5	4	6	...	6.8	82	68	75	....	....	66 °	70.5°	75 °	63.7°	40	44	38	30	28	...	36	97	80	88.5	..	....

THE CHEMICAL INDUSTRY.

THE earlier history of the chemical industry was very fully given in Vols. I. and II. of THE MINERAL INDUSTRY, and in the following pages will be found accounts of the progress made during the year 1894 in two of its more important branches, the production of alkalies by the electrolytic process and the manufacture of sulphuric acid; while references to other departments will be found in the articles on the various substances. One important department, the manufacture of alum and sulphate of alumina, is treated under its own head in a monograph which is certainly the most complete account of that special industry yet published.

Notwithstanding the general trade depression, the sharp competition for business and the low prices which have ruled in this line of production as in others, the chemical industries have continued to grow steadily in importance and value, and to extend in all directions. In Great Britain especially, where the greatest progress has been made and these manufactures were earliest established, they have shown their strength and importance in new developments.

Perhaps the most marked feature of the industry during 1894 has been the continued growth of the electrolytic processes, which have now fully established their superior excellence and economy, and are gradually superseding the older methods everywhere.

In this country the pioneer in the industry and the leading manufacturer of alkalies, the Solvay Process Company, has shown its ability not only to hold the market at home, but to compete with the British manufacturers on their own ground, in a way which is fully described in the history of the chemical market in the following pages. The work of this company is being extended.

In Virginia the Saltville works are getting ready to work under the Castner electrolytic patents.

The chemical industry in this country has before it a great future. With all the favoring circumstances of a large and continually growing demand, inexhaustible supplies of raw materials of various kinds and cheap power, there can be no doubt that its development, which has only just begun, will be rapid, and that it will, before many years, reach very great proportions.

It is difficult to secure full statistics of an industry having so many ramifications and carried on in so many different countries. In the tables below and in

the statistics of the several countries are given such figures as can be obtained with accuracy.

IMPORTS OF CHEMICALS INTO THE UNITED STATES. (*a*) (IN POUNDS.)

Year.	Nitrate of Soda.		Bicarbonate of Soda.		Caustic Soda.		Sal Soda and Ash.	
1890.....	293,007,228	$3,090,900	916,355	$16,962	88,345,462	$1,882,728	360,521,656	$4,176,422
1891.....	219,712,640	2,579,930	1,500,663	26,936	68,154,226	1,700,532	347,822,902	4,509,611
1892.....	213,456,320	2,933,174	1,466,595	25,874	54,384,120	1,309,500	361,648,637	4,698,379
1893.....	257,626,880	3,673,537	1,380,426	23,136	52,116,492	1,171,878	348,972,506	3,982,772
1894.....	219,824,646	3,189,084	.....	.....	46,554,322	919,197	219,517,064	2,658,581

Year.	Other Soda Salts.		Nitrate of Potash.		Muriate of Potash.		Chloride of Lime.	
1890.....	21,664,033	$132,443	13,563,798	$408,460	63,733,938	$978,024	105,696,046	$3,314,548
1891.....	16,226,334	114,955	15,292,057	469,591	78,144,810	1,220,119	108,880,831	1,632,127
1892.....	40,954,822	284,853	13,012,087	382,771	70,227,971	1,098,267	109,888,561	1,962,084
1893.....	29,850,109	205,523	13,374,016	369,274	74,663,116	1,192,516	98,618,147	1,843,410
1894.....	17,667,314	132,385	9,375,950	249,842	101,597,074	1,540,081	96,256,251	1,697,038

(*a*) From the *United States Summary Statements of Imports and Exports.*

Nitrate of Soda.—The supplies of this imporant raw material continues to come chiefly from the beds of Chile and Peru. The area worked has been extended by the sale during the year of a number of beds by the Chilean government.

The total exports of nitrates from Peru and Chile in 1894 were 1,099,366 tons, this amount comparing with 943,570 tons in 1893 and 797,827 tons in 1892.

The discovery of nitrate deposits in South Africa is reported, and steps have been taken to develop this new supply.

The following statistics of the nitrate trade are furnished by Messrs. Mortimer & Wisner, of New York, who are accepted authorities in the trade:

NITRATE OF SODA TRADE.

(1 bag = 220 lbs.)	1887.(*a*)	1888.	1889.	1890.	1891.	1892.	1893. (*a*)	1894.
Imported into Atlantic ports from west coast S. A. from Jan. 1 to Jan. 1..Bags.	481,505	478,751	484,555	688,124	632,536	641,165	767,332	714,631
Imported from Jan. 1 to Jan. 1 from Europe..... "	.....	.....	.....	.....	18,802	5,862	16,712	.....
Total..... "	481,505	478,751	484,555	688,124	651,338	647,027	784,044	714,631
Stock in store and afloat Dec. 31 in New York..... "	42,940	81,843	21,209	33,954	50,685	14,034	36,838	55,067
Stock in store and afloat Dec. 31 in Boston..... "	.....	.....	500	.....	900	420	3,000	1,300
Stock in store and afloat Dec. 31 in Philadelphia ..... "	.....	.....	.....	.....	.....	.....	.....	.....
Stock in store and afloat Dec. 31 in Baltimore ..... "	6,000	5,200	300	2,500	2,000	1,000	5,100	2,000
To arrive, actually sailed..... "	.....	.....	.....	155,000	188,000	164,000	125,000	259,000
Visible supply to April 15..... "	.....	.....	.....	191,454	241,685	179,454	169,938	317,367
Stock on hand Jan. 1..... "	70,080	48,940	84,043	22,009	36,454	53,588	15,454	44,938
Deliveries December..... "	22,982	11,451	33,430	46,573	36,098	35,280	134,837	123,568
Total yearly deliveries..... "	502,645	440,648	546,589	673,679	634,207	685,158	754,560	701,202
Prices current Dec. 31..... "	2⅛c.	2⅜c.	$1.90	$1.70	$2.07½	$2.15	$1.77½@1.80	$1.95@1.97½

(*a*) Included in the deliveries of 1887 and 1893 are 23,678 and 9500 bags, respectively, shipped to European ports.

The New York Chemical Market in 1894.

General Market.—The beginning of the year found the market in an unusually dull and depressed condition, owing to the stagnation which afflicted the business of most consumers of heavy chemicals. The second half of 1893 had been unusually poor, and as a consequence of the "hard times" a number of contracts were cancelled or deliveries deferred. With such a beginning 1894 could not be expected to prove a prosperous year. The improvement in business has been even slower than was anticipated, and as a consequence the consumption in 1894 shows a falling off as compared with 1893. The unsatisfactory condition of the business of some of the large consumers of heavy chemicals, as for instance the glass-makers, had a marked effect on prices as well as on the volume of business. The jobbing trade also was duller than usual. Toward the close of the year it was noticeable that buyers had been more dilatory in contracting for the next year's supplies than in former seasons. And when they did come into the market they placed smaller contracts than usual despite the low prices, showing some uncertainty as to the prospects of business in 1895. Prices were uniformly lower than in 1893, and seemed to decline steadily until late in the fall. They were weaker than in previous years, and it was not until late in the year that they rallied and showed some firmness.

The returns of the Bureau of Statistics give the imports of heavy chemicals into the United States during 1894 as follows:

IMPORTS OF HEAVY CHEMICALS INTO THE UNITED STATES.

Article.	1893.		1894.	
	Quantities, Lbs.	Values.	Quantities, Lbs.	Values.
Soda ash	326,393,033	$3,803,746	294,088,101	$2,483,838
Bleaching powder	98,618,147	1.843.410	96.256,251	1,697,038
Caustic soda	52,116,492	1,171,878	46.554,322	919,197
Sal soda	22,601,871	179,293	25,428,963	174,743
Chlorate potash	3,881,791	481,839	4,599,969	573,154

Caustic Soda.—Various circumstances combined to make this the most interesting of the heavy chemicals. In January prices were 2½@2¾c. per lb. These values ruled steadily until the new tariff went into effect. The duty had been reduced 50%—from 1c. to ½c. per lb. Foreign makers began to push the sale of their product, but they were more than met by the Solvay Process Company, which reduced prices and gave to its customers the benefit, not only on new business, but on the undelivered balances of contracts which had been placed at the old prices. Competition increased rapidly and contracts for delivery in 1895 were taken at from 1¾@2¼c. per lb. according to test. But by far the most important point was the actual exportation of several lots of caustic soda to England. The United Alkali Company was selling caustic soda in England at from $10@$14 a ton more than in New York, and the Solvay Process Company at once invaded the domain of its competitor, once deemed impregnable. The result was the visit to this country of two prominent officers of the United Alkali Company, admittedly to confer with representatives of the home concern. It is to be presumed that some understanding was arrived at, for shortly afterward prices advanced and ruled firm. They closed at 2@2.25c. per lb. for contracts and

about 10% higher for prompt delivery. The year thus marked an era in the history of the trade. The high prices of former years are an impossibility unless the consumption should increase more rapidly than there is much reason to expect. The great natural advantages of the chief domestic maker in the way of extraordinarily cheap raw material make it a formidable competitor of the best-equipped European concerns.

Bleaching Powder.—The year opened with a very limited demand, and prices at 2.12½@2.30c. The imports of English bleach fell off considerably, but arrivals of German, French and Belgian goods were large, and these were offered at lower figures until prices declined, and contracts were placed at 1.75@2c. per lb. These figures, made by the United Alkali Company, had a deterrent effect on the continental brands, so that while the latter had their best season during the first half of the year, the English article had its best demand in the second half. During the last three months of the year the greatest amount of business was done, and the last half of December showed a great improvement over the corresponding period of 1893, so that the prospects for 1895 are better than those for 1894 were in January of that year. Prices on December 31 were 1.75@2c. per lb. for English, and ¼c. per lb. less for continental brands.

Alkali.—Like all the other heavy chemicals, business in alkali was worse in 1894 than in the preceding year. Probably the volume of business in 1894 was not more than 70% of that of 1893. Prices declined steadily from 1@1.15c. in January to 0.80@0.90c. in September, though they rallied toward the end of the year, and closed at 0.90@0.95c., according to test and package. Many of the industries which consume alkali and carbonated soda ash were much depressed during 1894, and to this fact is due the corresponding dullness in these chemicals. The course of carbonated soda ash was naturally similar to that of alkali. It costs more to make the former than the latter, but there are still many consumers who prefer to pay a little more for carbonated soda ash, because they are accustomed to it.

While, all things being considered, the volume of business done in heavy chemicals in 1894 was not so small, prices ruled unprecedentedly low, and the year's business was not a satisfactory one. The long delays and uncertainty connected with the tariff bill were to some extent responsible for the depression of the first half of the year. We may not unnaturally expect an increase in business during 1895, but as for an advance in prices that is another thing.

The Acid Market.—In many respects the acid market in 1894 was a repetition of the market as it ruled during the second half of 1893. During the first half of 1893 a fair business was done, but in July the demand, owing to the stagnation in the business of consumers, dropped off suddenly, so that the volume of business done from July 1 to Dec. 31, 1893, was considerably less than that of the preceding six months. In 1894 the situation was reversed, in that the depression and dullness were greater during the first half, although it must not be inferred that during the second half the volume of business was at all satisfactory. The increase has been gradual and not great, and 1894 will be remembered as a poor year.

It is impossible to give even an approximate estimate of the total production of acids in the United States during 1894. Were the manufacture of acids con-

fined to those who are engaged exclusively in that work, it would be a very difficult matter to collect statistics. But as it is, the acid manufacture is so largely carried on in connection with other industries, such as fertilizer manufacturing and oil refining, that the task becomes impossible. All that can be stated with certainty is that the production of acids was less in 1894 than in 1893, just as it was less in the latter year than in 1892, although the difference may not be so great between last year and 1893 as it was between the latter year and 1892.

Consumers generally, by reason of the depression in business, took less acid than usual, about the only users who kept up a nearly normal consumption being the oil refiners. And even in this line the chief refiner, the Standard Oil Company, manufactures its own acid in more than sufficient quantity. The consumption of acids is so widely distributed that a general business depression, even though it be slight, affects the acid trade to a marked degree. Without exception acid factories ran on greatly reduced chamber capacity during the year.

The comparatively low prices of brimstone during the year did not induce any acid makers to abandon the use of pyrites. The prejudice which for a time consumers had against acid made from pyrites has been dying away until it can hardly be said to exist to-day. There is always, on the other hand, more or less uncertainty as to the price of brimstone. Moreover, it is not an easy matter to change a plant adapted for burning pyrites for one suitable for the use of brimstone. The majority of acid manufacturers use both brimstone and pyrites, the largest using the latter principally. Some consumers, however, still prefer "brimstone acid."

Prices ruled fairly steady during the year, but lower than ever before, and with a slight declining tendency. The actual decline over 1893 was not great, but the general range of prices has been lower. Where a lot of sulphuric acid could have been sold for 90c. per cwt. in 1893, it would have been difficult to get 80c. for it in 1894. For large quantities the difference in price was not so marked, but the average price was certainly lower in 1894. So steadily dull was the market throughout the year that it cannot be said to have had any decided features. If it had any, it was the tendency toward hand-to-mouth buying displayed by consumers. The latter have become so accustomed to declining prices that the possibility of an advance is regarded by them as too remote to be taken into consideration, and they have not done their usual amount of contracting, since makers could offer no inducement in the shape of still lower values. The makers themselves were not anxious to book orders calling for delivery through the year, at the low prices prevailing. They regard a slight advance as more probable than a further decline. It seems certain at this writing that the improvement, when it does come, will be so slow and gradual as to be without much effect on prices. No acid plant in the United States is running on anything like full capacity, and an increased demand will simply mean an increase in production. The former will have to be considerable before the limit of the latter is reached. Even then the prices of a few years ago will never again obtain. Raw materials are cheaper, and it is to the reduced cost of production brought about by scientific processes and economical management that makers must look for their profits in the future.

An attempt was made in the fall to organize a combination of manufacturers

for the purpose of getting better prices. Several meetings were held, but really, to speak of the attempt seriously would be to give it undue dignity.

Prices closed as follows per 100 lbs. in New York and vicinity for large lots: Sulphuric, 60°, 60@70c.; 66°, 65@85c.; "chamber" acid, 50°, $5.75@$6 per ton; muriatic, 18°, 75@85c.; 20°, 80@95c.; nitric, 36°, $3.10@$3.50; 40°, $3.90@$4.35; 42°, $4.35@$5.

Brimstone.—The course of the brimstone market in 1894 was regular. Throughout the year it ruled steady and was without marked features or disturbances of any sort. Prices fluctuated but little; they were steady and uniformly low. The quotation of $16@$17 for best unmixed seconds* ruled during the entire year.

The consumption of brimstone, as shown by the imports, was greater in 1894 than in 1893. According to the Bureau of Statistics of the Treasury Department, the imports during the year just past were 124,467 tons of which about 110,000 tons were Sicilian brimstone and 3000 tons Japanese. It is difficult to give an estimate of the imports of "recovered" sulphur (by the Chance process), but various users, chiefly paper men, place the figure at over 10,000 tons.

The increased consumption of brimstone in 1894 over 1893 is directly attributable to the decreased cost. Consumers, notably Southern fertilizer manufacturers who make their own acid, bought more freely than they would have done had prices been higher. Taking it all in all, the year was not a bad one, though prices were low. But as this fact chiefly concerns the Sicilian producers, American consumers have no ground for complaint.

Throughout the year consumers bought merely as their requirements called for, from time to time. There was but little contracting. Buyers waited until the last moment, then placed an order with the broker, which was cabled by the latter to Sicily.

The low range of values last year was due to the depressed business conditions abroad. Banks in Sicily are no longer as accommodating as they once were in the matter of loans. Formerly the brimstone producers could borrow money on their product and were thus able to hold the latter for a rise. Of late they have been forced to dispose of the output as soon as it was mined. By thus forcing it on the market lower prices were inevitable. The expectation is that an advance will take place in 1895. The chief reason adduced in support of this hope is that the production of Sicilian brimstone has been and is decreasing, owing to the inability of the smaller producers to work at a profit at the prices which ruled during 1894. Only the larger and wealthier concerns, it is claimed, can operate at present without a loss. A number of circumstances prevent the extensive introduction of labor-saving devices in Sicily. The population is as one man against it. People have not forgotten the uprising, some months ago, of the Sicilian mob—one of the worst in the world.

*"Best unmixed seconds," commercially speaking, means brimstone which is from 98% to 99½% pure. "Thirds" are from 96% to 99% pure, and rule from $1 to $1.25 less than seconds. "Recovered" sulphur sells for $2 to $3 more than seconds, owing to its purity and to its excellent appearance.

Electrolytic Methods of Alkali Manufacture and Production of Chemicals.

By Titus Ulke.

Electrolytic Caustic Soda and Chlorine.—The principal electrolytic methods of alkali manufacture were discussed in The Mineral Industry, Vol. II., pp. 121–140, and attention was called to their great and growing importance. The following notes will supplement this information and bring it up to date. Heretofore failures of such methods have been caused by the difficulty, first, of converting more than a small portion of the salt into caustic; second, of separating the cathode and anode solutions; and third, of constructing indestructible anodes. The chlorine generated, if not prevented by suitable means, combines with the caustic, and at ordinary temperature forms alkali chloride and hypochlorite, and at higher temperatures alkali chloride and chlorate:

$$2\ NaOH + 2\ Cl = NaCl + NaClO + H_2O.$$
$$6\ NaOH + 6\ Cl = 5\ NaCl + NaClO_3 + 3H_2O.$$

However, the chief difficulties encountered by electrolytic methods may be considered conquered. The chemical firm of Griesheim am Main, Germany, had already solved the problem of the commercial electrolysis of alkaline chlorides in 1890, and since then has marketed caustic potash, soda, and also chlorine, liquidized by pressure and shipped in steel receivers.

There are three principal methods for producing chlorine and caustic soda by electrolysis: 1. The decomposition of the chloride solution with electrodes not absorbing the products of electrolysis. 2. The mercurial process, in which mercury is used as a cathode to form a sodium amalgam. 3. The dry process, or electrolysis of fused chloride of sodium or potassium. Greenwood's process belongs to the first category, and Castner's to the third. The electrolysis of fused salts, it is said, presents so many difficulties, owing to the low efficiency, high electrical resistance, and large wear and tear of apparatus, as to render success in that direction doubtful.

Greenwood Process.—This process, as used by the Caustic Soda and Chlorine Syndicate, Limited, is as follows: The cells employed are rectangular vessels of slate or iron, covered with plates of cement, in which are placed openings for feeding in salt and taking off the chlorine generated. The neither cheap nor very durable porous diaphragms are built up of V-shaped porcelain gutters, calked with asbestos. Iron plates or wire screens form the cathodes; the anodes consist of blocks of retort carbon, which are united to large plates by filling in the spaces with type metal. When the solution has reached about 10% of caustic soda, the electrolytic process is interrupted, and the solution is worked up into caustic or into carbonate by evaporation, and by removing the salt crystallizing out during the concentration.

As mentioned above, the anodes are gradually attacked by nascent chlorine, and are consumed in 6 to 8 weeks. The chlorine and the carbon form a volatile compound, which slightly contaminates the chlorine gas. This difficulty may be avoided by using anodes of ferro-silicon or of similar material. Basing their views on detailed calculations, expert engineers have come to the conclusion that the cost of plant and the running expenses of the electrolytic process do not

prevent it from competing favorably with the Deacon and other processes. With a motive force of 2400 horse-power, 18 tons of salt may be decomposed daily, producing 8355 kilograms chlorine, equivalent to over 20 tons of 30% chloride of lime, and 9400 kilograms caustic, equivalent to about 32 tons of crystal soda. The total cost of making these products with cheap water-power may be taken at less than $1000.*

The Castner Process.—The essential feature of this process is the employment of a moving body of mercury, which, it is claimed, completely separates the products of electrolysis, and by its movement takes the place of a diaphragm. The amalgam formed by the electric action is decomposed electrically as rapidly as it is formed. The cell, which is divided into three compartments, can be continuously rocked or tilted, so as to give to the contained mercury a flowing motion from side to side. The two outside compartments contain the alkaline chloride solution and carbon anodes, while the middle compartment contains an iron cathode and the caustic solution. The salt or chloride solution continuously circulates through the outside compartments, wherein it is electrolyzed and then returns to saturators, where it is recharged with salt. The electric current, traversing the salt solution, liberates chlorine and also forms sodium amalgam. The chlorine escapes from each cell, through an aperture provided, into one large collecting main, while the sodium amalgam, by the continuous back-and-forward tilting of the cell, passes to the center compartment, where it acts as an anode during the passage of the current to the cathode, the sodium being liberated and going into solution as caustic. The energy stored in the sodium amalgam is thus made use of electrically to aid in carrying on the process. A regulated quantity of water is admitted hourly to the center compartment of each cell, causing the pure solution of caustic to overflow through a discharge pipe into a large collecting pipe. All the cells are connected with four mains: one for the supply of saturated brine, one for the return of the electrolytic solution to be saturated, one for collecting the chlorine, and one for collecting the caustic.† A plant for carrying on the process is now in course of erection at the alkali works of the Mathison Alkali Company, in Saltville, Va. The large demonstrative plant at the works of the Aluminum Company, Limited, Oldbury, near Birmingham, England, consists of 30 cells, arranged in two parallel rows of 15 each. The current is taken from a Compton dynamo, having an output of 1100 ampères at 60 volts, the current being divided so as to apply about 550 ampères to each row. Of the 15 cells in each circuit connected in series, 14 are always kept in use, one being held in reserve and ready to put in circuit, if for any reason it is necessary to stop one of the 14. Each cell is 6 ft. long, 3 ft. wide and 6 in. deep, and has an active anode surface of about 12 sq. ft. It takes a current of 550 ampères at 4 volts to decompose 56½ lbs. of salt daily, or 0.48 grams of salt per watt-hour. We have examined figures of a continuous test run made with the plant from Aug. 15 to Dec. 1, 1894. The figures and estimates refer to the first row of cells (one-half of the whole plant) and 50 horse-power. The other half of the plant was in operation, but no figures as to it were obtained. The inventor claims, however, that the second row of cells

Chemiker Zeitung, 1894, No. 84. † *Engineering and Mining Journal*, Sept. 22, 1894.

would yield exactly the same results as the first if submitted to such an exhaustive trial, measurements recorded and products weighed. The total daily capacity of the entire plant (28 cells), is shown to be 1120 lbs. of pure caustic, and 992 lbs. of chlorine for an expenditure of 100 indicated horse-power. During the test run the same solution was in continuous use, being recharged with salt at regular intervals. There was little or no wear on the carbon anodes, and no appreciable loss of mercury. The mercury is never removed from the cells. The average analysis of the solid caustic produced was as follows : Sodium hydrate, 97.75%; sodium carbonate, 2.20% and sodium chloride, 0.05%, equal to 78 or 79%, Liverpool test. The chlorine produced is all absorbed for the purpose of making chlorate of potash.

The figures obtained in the test run demonstrate the following results : 1. The electrical efficiency or yield per ampère is 88% to 90%. This high efficiency is partly due to the fact that the sodium is removed from the mercury electrolytically as rapidly as it is formed, so that the mercury in circulation rarely contains more than 0.02% of sodium. 2. No hypochlorites are produced. The difference between the theoretical and actual efficiency is not represented by chlorine combining with caustic, but by chlorine and sodium recombining to form salt. 3. The electrolytic solution is in continuous use. 4. The wear of the carbon anodes is exceedingly small, owing to the absence of hypochlorites; anodes of ordinary pressed carbon may be employed instead of retort carbon. After being heated white-hot by a powerful electric current, the anodes are said to resist the action of chlorine. 5. The electro-motive force required for each cell is about 4 volts for a current of 550 ampères. 6. Each cell decomposes 56½ lbs. of salt daily, producing 38½ lbs. of caustic, and 34½ lbs. of chlorine in 24 hours, with an expenditure of 3½ indicated horse-power. 7. The caustic solutions produced contain 20% of caustic soda, and produce by direct evaporation a solid caustic with 97.75% sodium hydrate. 8. The chlorine gas is of 95% to 97% purity, the balance being hydrogen. 9. The cells are simple in construction and require little attention.

Electrolytic Potassium Chlorate and Carbonate.—In 1892 the United Chemical Works at Leopoldshall, Germany, began the manufacture of potassium carbonate and chlorine by the Spilker & Lowe process, a method similar to the Greenwood process described above, but difficulties encountered at the start have not been entirely overcome.

The manufacture of potassium chlorate at Vallorbes, Switzerland, has been successfully accomplished since 1890. The Orbe River, which falls 66 meters with 3000 horse-power at Saut-du-Day, furnishes the motive power. The old part of the hydro-electric factory, in operation since 1890, has 10 Thury dynamos of 160 horse-power each, 9 working continuously day and night, the tenth being in reserve. Each dynamo is driven direct by a turbine one meter in diameter, which makes 350 revolutions per minute. The Thury dynamos are six-pole machines, weighing 6 tons each, and develop 100,000 watts. In the new plant 10 dynamos of 500 horse-power each, and with a tension of 250 volts at the poles, are installed. The electro-chemical works receive the current by cables of large size. A kind of three-wire system is used to distribute the electric energy

to the baths, that is to say, in one half of the series of baths the positive poles are connected to the negative poles of the other half. The common point of the two groups of series is connected to a cable insulated from the earth; this cable terminates in a copper strip connected with 10 machines by means of 10 conductors, one half going to the positive poles of 5 machines, and the other to the negative poles of 5 others. The result of this arrangement is that they can stop a series of baths by stopping the corresponding dynamo. The electrolytic tanks have partitions separating the cathodes from the anodes and preventing the reducing action of the hydrogen upon the chlorate of potash formed. It is necessary to have the potash produced at the cathode react upon the free chlorine at the anode. The cathodes are iron plates; the anodes are made of thin sheets of platinum, about 0.1 mm. thick, supported by an iron frame protected by rubber. The electrodes are fixed on the bottom of the baths. These are electrically insulated from the floor by porcelain cups filled with oil, allowing the workmen to touch the vats. The electrolyte is a 25% solution of chloride and the electromotive force 5 volts at each vat. The temperature is raised by regulating the current, which alone furnishes the necessary temperature for the transformation of the hypochlorite into chlorate. The chlorate of potash formed is almost insoluble, and crystallizes in the bath. It is taken out, washed, strained and recrystallized to a pure chlorate. The volume of the hydrogen gas, formed by the secondary action of the potassium upon the water, is about 100 cu. meters per ton of the chlorate obtained.

As the quantity of liquid treated daily exceeds 50 cu. meters, and as the recrystallization of the chlorate and chloride solutions also necessitates the handling of large quantities of solution, pumps driven by electric motors are used. Before the new installation of the two dynamos of 500 horse-power, the Vallorbes works produced 400 tons per year, but the enlarged plant will double this output. The installation of the hydro-electric works cost 260,000f. ($52,000) for the mechanical work, which for 3000 horse-power (86f. or $17.20 per horse-power) is low. With the dynamos, construction, etc., the cost of the establishment is less than 600,000f. ($120,000), or below 200f. ($40) per horse-power. From a chemical point of view the above process possesses many advantages: the raw material is abundant and cheap; the process leaves no obstructing residue, and is not tributary to the great chemical works, which were, until now, the only manufacturers of chlorate. According to Haeusserman and Naschold, 67% and 80% respectively, of the theoretical amount of potassium chlorate and of caustic potash, calculated from the total quantity of electricity supplied, are obtained. A porous diaphragm is used to hinder the reduction of the chlorate by the hydrogen evolved at the cathode. W. T. Gibbs and St. P. Franchot (1893) claim that a diaphragm is not necessary if the cathode be surrounded by copper oxide, which can always be reoxidized by heating in the air.

New potassium chlorate works, run by hydraulic power, have been started by the Société d'Electrochimie in 1894, at St. Michel de Maurienne (Savoie), France. These works at present only partially utilize the 6000 horse-power at their disposal.

Electrolytic Bichromate.—In the course of the manufacture of bichromates of the alkalies, we obtain raw liquor containing both neutral chromate and free alkali. Heretofore this liquor was acidified with sulphuric acid, and the resulting mixture of alkali sulphate and alkali bichromate separated into its constituents by fractional crystallization. In Haeussermann's process the above acidification of the liquor is replaced by electrolysis. The platinum anodes and iron cathodes are separated by porous partitions. The chromate liquor is placed in the anode compartment, and water around the cathode. The electrolytic reactions are as follows:

$$Na_2CrO_4 = Na_2 + CrO_4;\ CrO_4 = CrO_3 + O.$$
$$Na_2 + 2H_2O = 2NaHO + H_2;\ Na_2CrO_4 + CrO_3 = Na_2Cr_2O_7.$$

Caustic soda and hydrogen collect at the cathode, while the anode solution is transformed into bichromate of soda and escaping oxygen. The resistance to the passage of the current, at first very large, on account of the low conductivity of the water, is soon reduced, owing to the formation of caustic soda, which is a good conductor. The above process yields caustic soda as a by-product, instead of sodium sulphate; makes the use of sulphuric acid and the separation by crystallization of bichromate and sulphate unnecessary, and thus indicates an important step in the progress of bichromate manufacture.

Electrolytic Bleaching Solutions: Hermite Process.—In this process the electrolyte is either a solution containing 50 grams sodium chloride and 5 grams magnesium chloride to the liter, or an aqueous solution of carnallite ($MgCl_2$, $KCl_1 + 6H_2O$). On closing the electric circuit, sodium or potassium hypochlorite is the principal reaction product. Appreciable quantities of caustic alkali cannot be formed, owing to the presence of magnesium chloride. The current is passed until the bath has the requisite bleaching strength. If the bath, after using, has fallen below its normal strength, it is brought up again to normal strength by repeating the electrolysis. The loss of material is very small, whereas formerly, in bleaching with chloride of lime, large quantities of the latter were continually used up, and had eventually to be carried off as worthless calcium chloride in the waste liquors. A large bleaching establishment at Cardiff, England, has replaced a daily consumption of 2000 kilograms chloride of lime with a bleaching solution requiring a current of 100,000 watts during 24 hours.

Electrolytic bleaching may be as easily applied to textile fabrics as to paper pulp. Extensive plants are now operated by the London Electrical Bleaching Company, S. D. Warren & Co., and W. Russel at Boston, and Ch. de Montgolfier at La Haye, Descartes, France.

Electrolytic Chlorine and Ozone.—These are now employed on an extensive scale for bleaching oils, resins, varnishes, dextrine, and similar substances. Siemens & Halske state that in bleaching dextrine chlorine and ozone supplement each other's action, and Kellner finds that the bleaching action of chlorine is greatly increased by the silent discharge, or by the passage of an electric current producing sparks. At Bethnal Green, London, a large plant is now successfully making ozone from oxygen with alternate currents of 10,000 volts.

Sulphuric Acid Manufacture in the United States.

Dr. George Lunge, in reporting the results of observations made on his visit to the United States last year,* says that in the United States he finds both old and modern devices in use; certain acid plants with modern improvements bid fair to surpass those in the best European works. While many of the chambers used in America are old, too large, and are supported by heavy wooden frames, the newer ones are provided with iron frames. A larger number of smaller chambers are now preferred; for example, 12 chambers 8.2 meters in length—these chambers consuming but little nitre—or three larger chambers with room between them for interposing Lunge-Rohrmann plate towers.

The draught in the chambers is obtained, as at Freiberg, Saxony, by means of fans, with wings of hard lead or lead-coated wood mounted on iron axles, which run in close-fitting simple lead journals. The fans are placed between the Glover tower and the first chamber; between the last chamber and the Gay-Lussac tower, or at both places, and are frequently run by electric motors to avoid shafts and gearing.

Pyrites roasting furnaces of the Spence type are used in many places, but although saving labor they do not produce a favorable impression on account of the noise they make and the difficulty of running them. The best furnace for fines is Frasch's. Falding builds the walls of the roasters of hollow brick, thus keeping them cool, and conveniently securing heated air.

Of special apparatus a practical siphon arrangement is especially noted.†

For sulphuric acid concentration platinum vessels alone, or in combination with cast-iron vessels, are commonly employed, either in the form of closed retorts, or as vessels with a cooled lead cover (Faure-Kessler system). Stills made of Heräus' gold-platinum alloy are used in several works with excellent results for pure acid. For impure acids, and especially for those containing much iron, cheap cast-iron vessels are used with advantage. The consumption of fuel, however, is less with platinum than with iron stills. Nitro-glycerine waste acid, after denitrification with steam, is passed into the sulphuric acid chambers, where it deposits a large part of its sediment, and is then further concentrated. Falding effects concentration of sulphuric acid cheaply by placing between the pyrites furnace and the Glover tower a second and a smaller Glover tower, supplied with denitrified acid from the main tower which has been concentrated to 60° B. The entering gases being very hot, this small Glover tower rapidly concentrates the acid to 66°. It is necessary, of course, to construct the small tower of material which is capable of resisting acid of this strength.

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* *Berg- und Hüttenmännische Zeitung*, Nov. 2, 1894.

† This device is described in the *Zeitschrift für Angewandte Chemie* for 1894, p. 133.

Some Improvements in the Manufacture of Sulphuric Acid.

By W. H. Adams.

The year 1894, with many severe trials and economies enforced in all manufacturing industries, has shown that the manufacturers of sulphuric acid in the United States are still, as they have been since 1886, in advance of old world practice. The year shows a quantity manufactured equal to 710,000 tons of commercial acid 66° Baumé. This is about the same amount as was manufactured during the year 1893, in spite of the depressed times. A notable increase in the consumption of brimstone has taken place, because entirely new channels for this imported product have been opened since sulphite processes for bleaching have obtained a firm foothold among paper manufacturers of this country. But for this almost new demand there would have been a falling off in brimstone imports. It will be noted elsewhere that contrary to all calculations brimstone has come into the country during the year 1894 in about the same quantities as in previous years.

Some years ago the writer foreshadowed decided changes in apparatus for the concentration of weak acids.* In the present article there are given descriptions of several novel features which have been brought successfully into use during recent years.

Roasting furnaces and kilns are first considered with reference to improvements which have been made to types existing several years ago.

Fig. 1 shows a new type, a combined pyrites and brimstone kiln. This will be appreciated as a departure of value for use in such acid works as are conveniently located to both pyrites and brimstone supplies. Many works originally erected to burn brimstone have added pyrites burners, either kilns for "spalls" ore, shelf or mechanical furnaces for "fines" ores. In nearly all cases the brimstone burners have been retained in such works, acting as dust catchers for the new pyrites plant, and are in condition for future use should occasion demand. For new construction of pyrites kilns, and in cases where the output of acid is small, it will be advantageous to erect this combined burner, and the cost will be very little in excess of the present well known iron-front kiln.

Changes have been made at several of our largest factories in the manner of feeding pyrites into the kilns. The usual method is to place the weighed "spalls" pyrites in front of each kiln and each charge of ore is then carefully shoveled into the kiln on the burning ore. This requires the active work of two men for several moments, during which time the kiln doors must be opened wide. Now, to open these doors (equal in area to about one-eighth the gas space in the kiln itself) each half hour, the usual custom, is a crude method which results in all sorts of annoyances and upsets calculations on tower and chamber workings. In the improved procedure the ore is carried in an iron car along a line of rails on the center wall or on top of all the kilns, and the cars can thus dump each charge into a double bell hopper on top, and in the center of each kiln. Three men on each shift can thus attend to the feeding of the kilns, remove the cinders and pot the niter for a plant consuming 30 tons of pyrites daily. It should be stated that cinders are removed into iron cars on a track below the

* *Trans. of Am. Inst. of Min. Eng.*, Vol. XV., p. 381; Vol. XVI., p. 496.

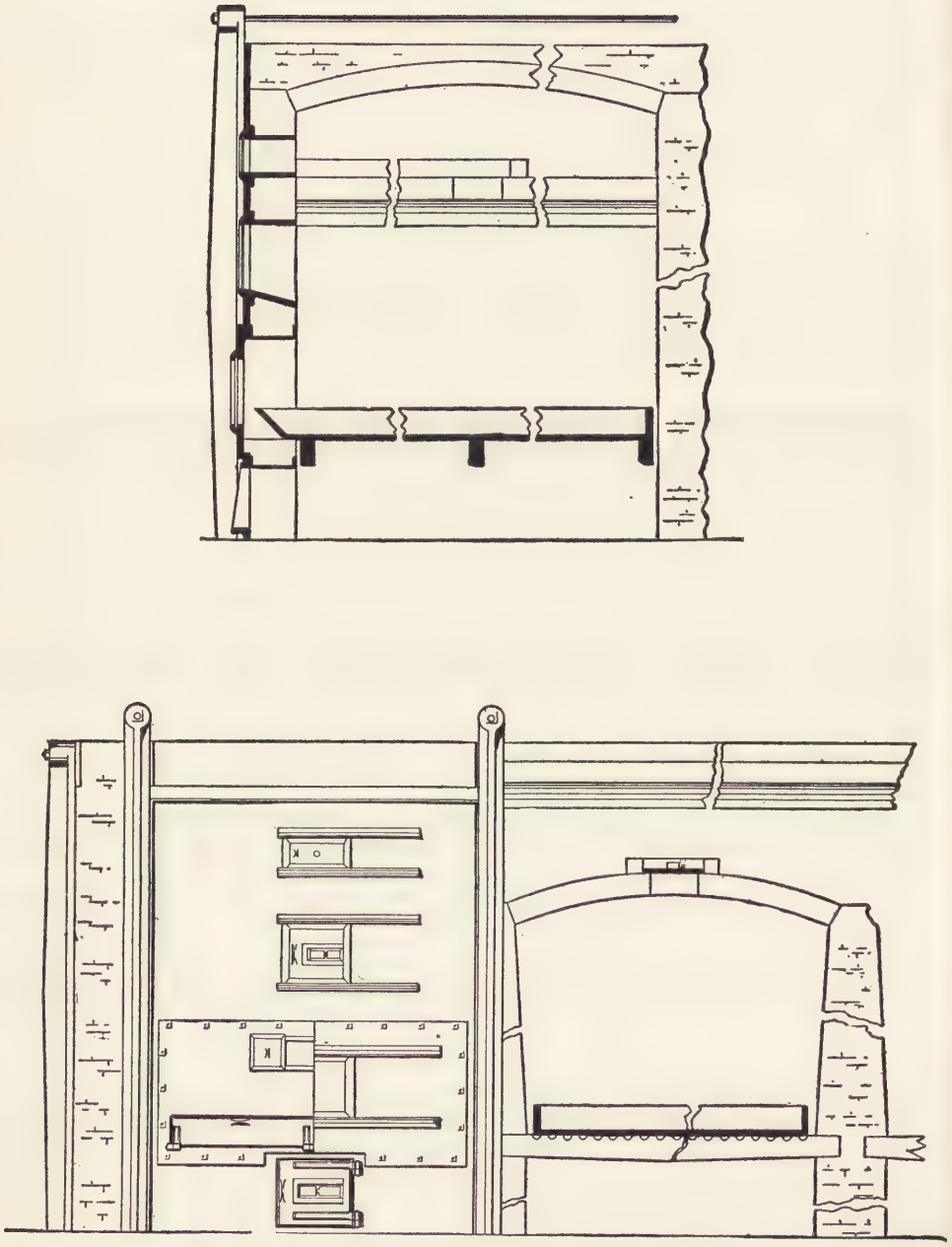


FIG. 1.—COMBINATION SULPHUR AND PYRITES BURNER.

grate bars and the base of the kilns, thus modifying and bettering one of the most disagreeable features of old-time kiln practice.

Mechanical furnaces have been greatly modified and changed within the past five years. The best type (in general use throughout the United States) is the 4, 5, 6 and 7-hearth Spence furnace, so successfully applied by manufacturers of sulphuric acid since 1884, and which is now taking the lead over all classes of furnaces for roasting pyrites ores. The accompanying illustration, Fig. 2, shows one of the newest construction, a five-hearth Spence, which admits of so wide a range in working as to answer nearly all requirements. The double furnace here shown consists of five hearths on each side of a central wall (pierced for air tubes), thus giving ten hearths 22 ft. long and 54 in. wide. Thus 900 sq. ft. of area are obtained in each double furnace of this type, and practice has proven this area capable of roasting at the rate of 30 lbs. per sq. ft., or a total capacity of 27,000 lbs. of 46% pyrites roasted in 24 hours. The cost of this furnace is about $4000, and the roasting is accomplished without the aid of fuel, except in cases where the pyrites contains less than 30% of sulphur. In this case producer gas or oil gas is used, passing under the floor of the first bed and thence upward through air-tight flues built into the central wall. It has been found that in ordinary cases only the lower shelf requires to be heated, and therefore the fuel cost for even poor grades of pyrites is exceptionally low. The entire cost of roasting by means of this furnace, including labor, fuel, repairs, etc., varies from 30c. to 75c. per ton of pyrites. The ores entering the upper shelf through the hopper are automatically and mechanically passed from shelf to shelf until expelled thoroughly roasted. The top of the furnace is utilized to dry all ores before they are fed to the hopper. Elevator belts are provided to lift the ore to the hoppers or drying surfaces.

Another type of the Spence furnace is working satisfactorily in La Salle, Ill., in the chemical works of the Matthiessen & Hegeler Zinc Company. This is a muffle furnace with mechanical rakes and is used for roasting zincblende, the gases being carried to towers, chambers, etc., for the manufacture of sulphuric acid. It has seven hearths, one above another, each 54 in. wide, 50 ft. length of masonry. The arches are 14 in. above the hearth in the center; two are combined in one block, one of the long side-walls being common to both. The principal working doors occupy the full width of each end, while the free side-wall is pierced with numerous openings, giving access to the hearths, if necessary, but ordinarily tightly closed. The raw blende is charged from a hopper over one end of the topmost hearth, travels the length of that hearth, then drops through a slit near the end of the hearth to the next lower one, is carried in the opposite direction over that second hearth, drops near its end to the third hearth, and so on successively over the whole seven hearths; it is finally expelled fully calcined into a closed bin. The gases evolved in the process follow the course of the ore in the opposite direction, and are carried from the topmost hearth through a wide flue to the acid works.

The calciner is fired with generator gas. The fire makes three passes through the full length of the calciner, first passing under the first (lowest) hearth; then between the first and second hearths, then between the second and third hearths, the lower fire flues having the full width of the hearth. The flame is elongated

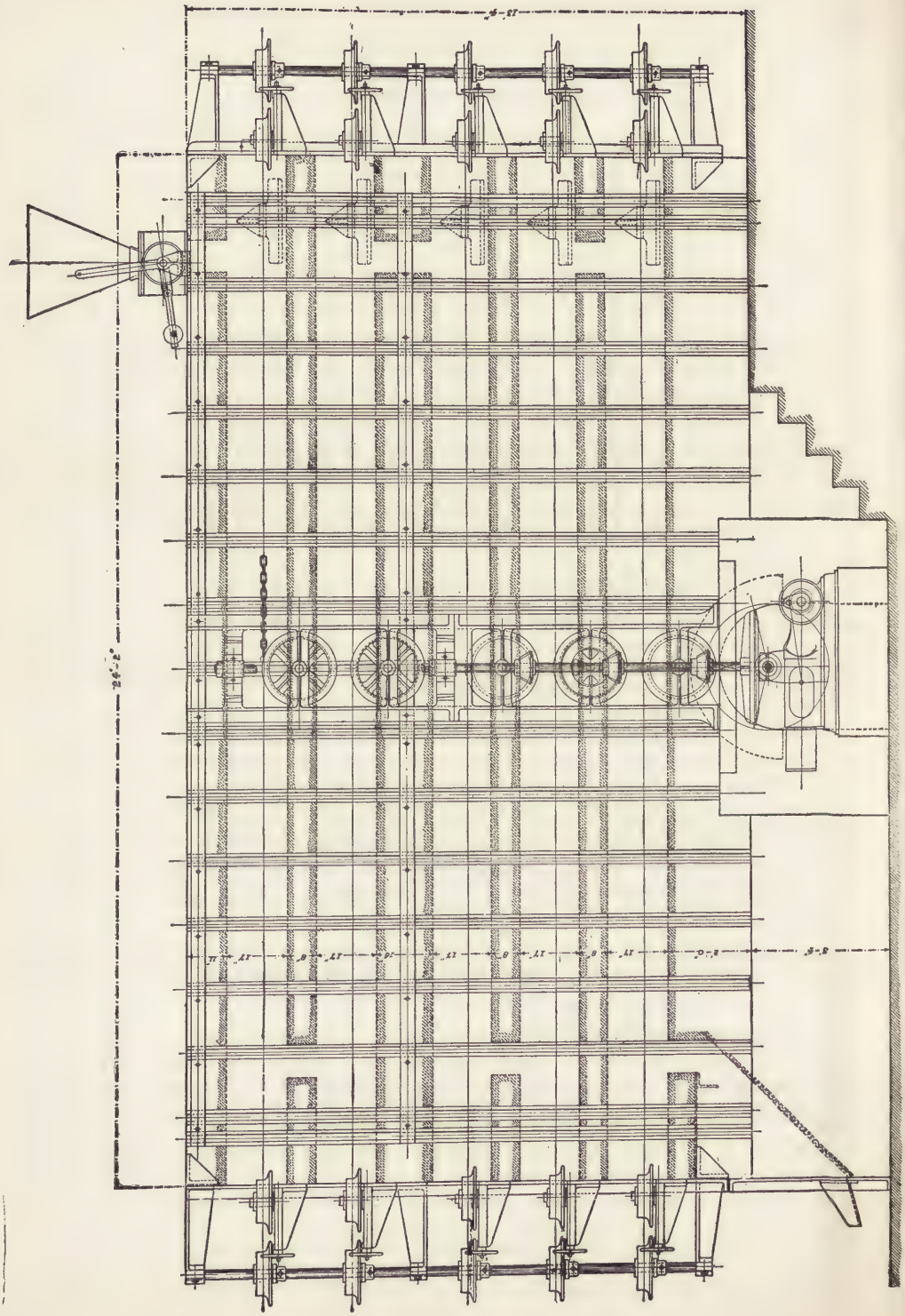


FIG. 2.—THE ADAMS-STENCE FURNACE.

by admitting the air necessary for the combustion of the generator gas at different points and in definite installments. From the calciner the fire gases pass outside of the building through an air heater in which the air used for oxidizing the blende is heated in an iron pipe. This air pipe is a low-pressure fan blast taken from the pipes which also supply the zinc furnce. The air is then further heated by passing under the lowest fire-flue of the calciner.

The rakes for moving the ore over the hearths weigh about 600 lbs. each and have their places on a frame in front of the hearth door at either end of the calciner; they are pulled in and through the furnace by means of iron bars to which they are hooked and which have just previously been pushed over the hearth from the other end. These iron bars are kept from running into the sides of the hearth by a guide loosely slipped over the end. The bars are moved by friction pulleys placed beyond the rake platforms at either end of the calciner. Rakes as well as bars remain exposed to the high heat of the calciner only a very short time. The raking begins on the upper hearth and ends on the lowest. It is done generally from 18 to 24 times in 24 hours. The two calciners in a block are generally so arranged that the charge hopper, and consequently the discharge end, are at opposite ends of the block.

The same rake which has passed over a hearth can later, by swinging round the platform on which it rests, be brought before the adjoining hearth and can pass over that in the opposite direction, and can finally by swinging the platform on which it then comes to rest be brought back to its original position.

The production of calcined blende by this double calciner averages 40,000 lbs. in 24 hours, equal to over 47,000 lbs. of raw blende, which comes to the calciner crushed to pass through a two millimeter screen. The fuel consumed is about 240 lbs. of an impure coal for each 1000 lbs. of calcined blende. The crew of the double calciner consists of two shifts of four men each—two for each end of the furnace, besides a fireman and helper in each shift, who attend to three such calciners.*

The Lunge Plate Tower.—This system properly belongs to any plant which is in advance of the practice of several years ago, but it has so often been referred to in the *Engineering and Mining Journal* and is so generally known as to need no special notice in this article.

The Modern Steel Frame Glover Tower.—The modern, shapely, fire-proof and economically constructed Glover tower, with its connections, will be appreciated by those interested in the subject as a step in advance of the plant usually erected for so many years past for this purpose. It is shown in sectional elevation in Fig. 3 and in transverse section in Fig. 4. The details generally require no explanation though special features may be noted. The entire base of the tower is useful for storage purposes; the cooler is so arranged that any overflow of acid which may occur from any cause simply passes into chambers 1 or 2. The lining is of most approved pattern, consisting of acid-resisting brick backed by cushions of silica, with supporting base-tiles, and a filling of pure lump silica. The distribution of acids throughout this tower is very carefully controlled by new and improved methods; the inlets for acids are visible at all

* [In the article on improvements in copper metallurgy under "Copper" will be found descriptions of several other modern and improved furnaces.—EDITOR M. I.]

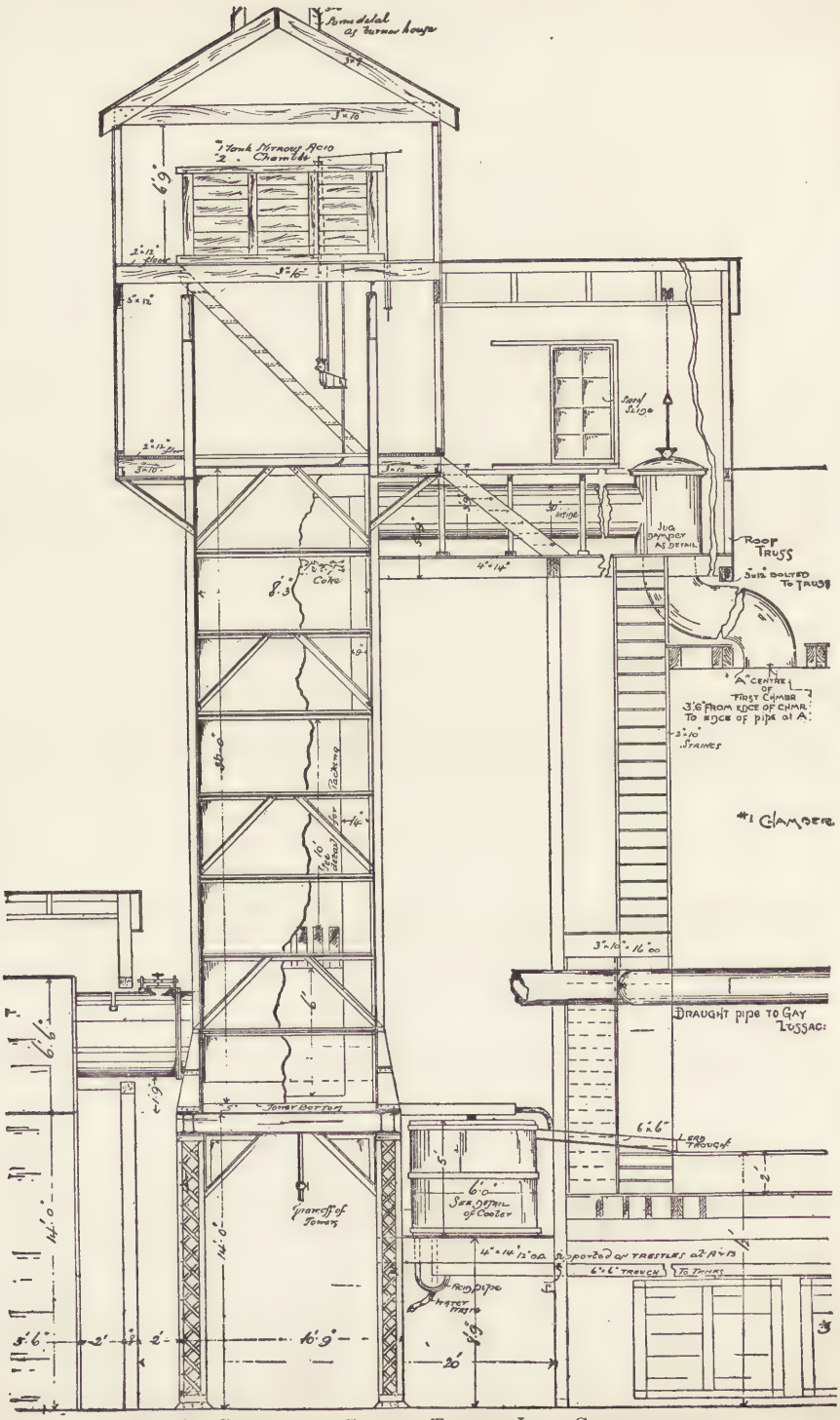


FIG. 3.—SECTION OF GLOVER TOWER, IRON CONSTRUCTION.

times, and the action of the gases can be regulated at will. Dust chambers of approved pattern are placed before the towers, and in some of the newer constructions float-dust screens are interposed to prevent choking the towers.

The Barbier Tower System for Manufacture of Sulphuric Acid Without Chambers.—A new applicant for favor at this time, which has had a successful

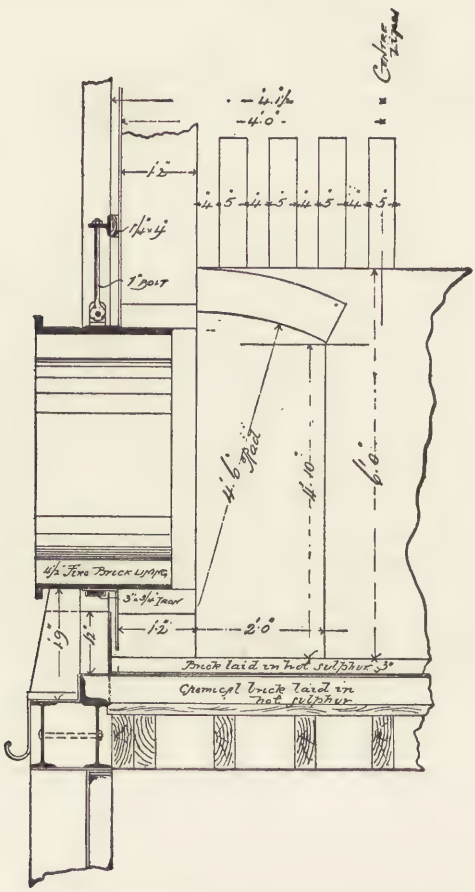


FIG. 5.—TRANSVERSE SECTION OF GLOVER TOWER.

initial trial for the past three years and has now come to the working stage, is the simple and practical tower process of Mr. E. J. Barbier, Paris, France (U. S. Patent No. 535,882, March 19, 1895). It is shown in Fig. 5.

The illustration shows his apparatus in section and it will be fully understood by examining a few of the details of construction. L is the brimstone or pyrites burner, communicating through dust flues L^1 L^2 with the first tower R^1 of a series of communicating reaction towers, R^1 to R^4. These towers are placed adjacent to one another and a flue leads from one tower to another, preferably as shown, from the top of one tower to the bottom of the next adjacent tower. Leading from the tower R is a flue or chimney *e* which serves to draw the air and

gases through the apparatus. Arranged beneath each tower is a pan or other collecting vessel *a* which collects the acid from each tower. These pans are arranged one above the other in cascades, and are connected one to the other by drain pipes a^1.

One or more pans may be arranged within the chamber L^1 and under the last of the cascade a fire is built in the grate S, the gases out of which pass off through the flue S^1 S^1 and under the pans *a*.

The towers are lined with acid-resisting material *r*, and are partially filled with tiers of perforated pots *g*, of a special construction. At the bottom of each tower is a perforated bottom *c* which prevents the acid from falling into the pans *a* with too great force. Suitable jets or sprinklers b^1 b^1 are arranged in the

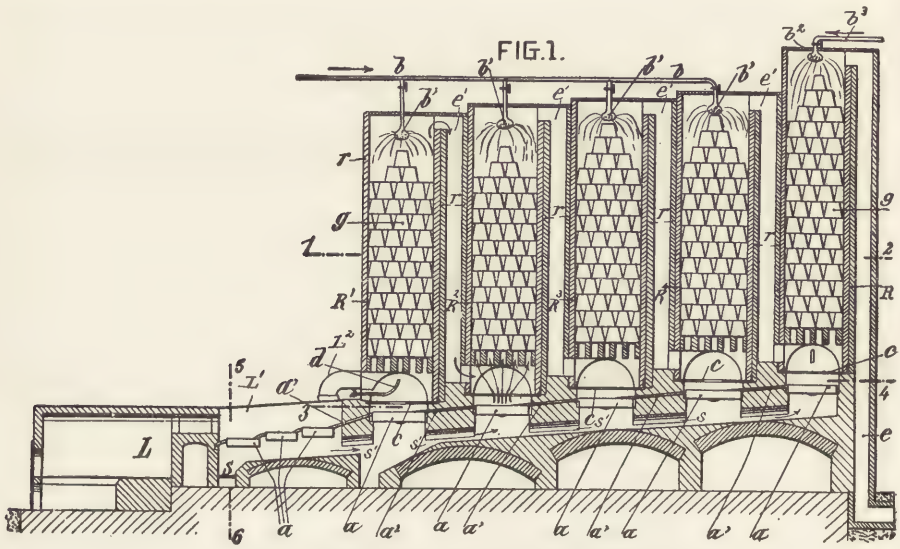


FIG. 5.—BARBIER'S SULPHURIC ACID TOWER.

top of the towers and are fed with dilute nitric acid, or sulpho-nitric acid, so called, by means well known. The last tower R of the cascade is a Gay-Lussac or absorption tower, supplied with acid by means of pipe b^3 and sprayer b^2.

The operation of this plant is easily understood. Fire is lighted in the grate S and the pans are filled with 50° Baumé sulphuric acid. The gases from the kiln pass into chamber L^1 over pans *a a* therein, and into tower R^1, carrying with them nitrous and aqueous vapors from the evaporating pan under this tower, and as they travel upward they meet the falling nitric acid. The result is the formation of sulphuric acid, which gathers in pan *a* to be heated and concentrated by the gases and the fire at S. Any excess of sulphurous gases pass over into the adjacent tower, where the operations and reactions are repeated, and thence through the series until it reaches R, where such gases as have not been oxidized are absorbed by the descending stream of acid. The sulphuric acid formed in the apparatus flows from pan to pan of the cascade, becoming more and more concentrated on account of evaporation of aqueous and

nitric vapors therefrom, and when it reaches the last pan *a* it will average 58° to 60° Baumé.

This seems to be the first practical solution of a problem which has occupied the attention of chemists since McDougal in 1848 attempted to do away with chambers and substitute therefor a tower containing Woolf bottles filled with nitric liquids, etc. The many attempts since that time have lived scarcely beyond their experimental stage, but this Barbier process will appeal to practical men as offering for the first time a working plant of dimensions from the smallest to the largest at moderate cost; which shall occupy very small space and is easy to manage, while its many new features assuring an acid cost as low, if not lower, than now rules among our larger concerns.

The construction cost of this plant is just about one-half that of equal capacity in chambers. Comparing still further the operations in France for several years past have demonstrated:

1. The entire output of acids by the Barbier process is 60° Baumé, which is entirely freed from nitrous vapors.

2. From 40 to 50 kilograms of 60° Baumé acid is obtained from each cubic meter of tower compared to 4 to 5 kilograms of say 52° Baumé acid per cubic meter of chambers.

3. Operating continuously with temperatures ranging between 50° and 100° C. permits of this tower plant being used to greatest advantage in countries where chambers cannot be used economically, while its use is equally advantageous in connection with chambers as universally erected.

4. A special generator for steam is not required as in chamber plants, as the evaporation which takes place in the pans and the addition of strong nitric water to the upper portion of the towers furnishes sufficient vapors for all the reactions.

5. Plants can be erected by the Barbier process to manufacture as little as one-half ton of 60° acid daily, an advantage never before offered by any style of chamber plant. This feature will appeal specially to all consumers of acids in isolated mine districts.

Broom's Surface-Heating Concentrator.—One of the latest improvements in plant for the concentration of sulphuric acid—a continuous process by which acid at 50° Baumé is carried through the different steps until delivered from iron stills at 66.1° Baumé, is illustrated in Fig. 6.

These concentrators are generally built in pairs, insuring the continuous working of the process, and so divided that one of the lines of pans can be thrown out of service during repairs while the other one continues to work.

The construction will be generally understood with but little explanation for details; A is the fire-box, which is especially designed to use fuel oil or producer gas, so regulated as to supply only the heat for the stills and for the proper concentration of the weaker acids. The entire heat from the fires under the stills passes through the pans B and C into D, which acts as the distributer of the radiant heat over the surfaces of the acid. E is constructed of iron and lined with lead, which is covered with a special firebrick protecting the lead from direct action of the heat and from the acid and acid vapors. The vapors from the surface fire are carried through the jug-damper G into the condenser H,

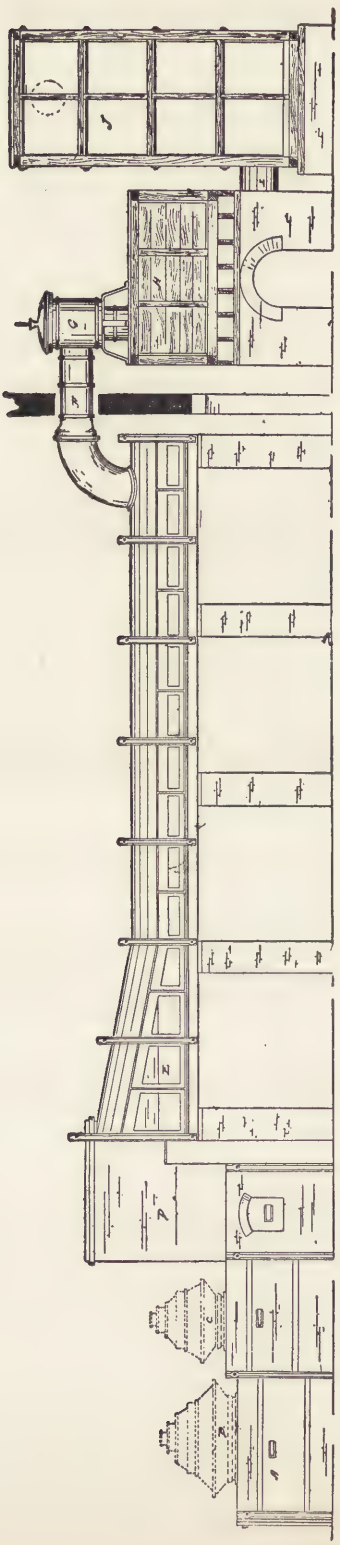


FIG. 6.—BROOM'S SURFACE HEATING CONCENTRATOR FOR SULPHURIC ACID.

which is specially designed to remove any acids which may be carried over during a violent ebullition in the pans. This vapor is carried further along, through the scrubber T, into the chimney of the works, or into any outlet which may be arranged for same. The capacity is so far in advance of any other form of concentrator, owing to the absorption of substantially all the heat which is generated by the easily controlled and steadily burning oil or gas jets, that this form of concentrator may be said to lead all other classes of apparatus erected for this special purpose. Two stills of platinum 36 in. in diameter and two iron stills of modified and new design, coupled to the system of pans here shown, readily yield an output of 70,000 lbs. daily of 66.1° Baumé acid. With two platinum pans 46 in. in diameter (the other apparatus as described) a yield of 120,000 lbs. daily of same strength acid can be averaged. The repairs are very light on the pans and the lessened consumption or deterioration of iron and platinum, owing to the steadiness of operating in this plant, is one of the most satisfactory features.

The cost for construction of a plant of this description varies with the service required, but in proportion to the amount of work done it is the least costly plant which has yet been practically applied and fully demonstrated. The cost of concentration (fuel, labor and incidentals) is the lowest ever reported for this essential step in the manufacture of strong sulphuric acid, not exceeding 75c. a ton, and in cases where conditions are favorable the cost sheets will show figures as low as 48c. a ton of strong acid, taking chamber acid at 48° Baumé and the finished product at 66° Baumé.

Several plants are now successfully operated with a fuel oil cost of 22 gals. per ton of acid, and the great changes which have been brought about by modifications of this new pan method (by elimination of the weak points inseparable to all initial processes of this character) warrant the statement that this substantially perfected acid concentration system, now in large use in this country, is the greatest step in advance which has been made for thirty years.

Utilization of By-products from Manufacture of Sulphuric Acid.—Bisulphate of soda (niter-cake) is commercially utilized by a new process (U. S. Patent No. 484,546, issued to E. J. Barbier) which differs in almost all respects from present practice.

Niter-cake is the by-product of a retort process and is obtained by conversion of say 600 kilos nitrate of soda into 750 kilos of bisulphate of soda—430 kilos of nitric acid, 92% to 95% mono-hydrate, being evolved and utilized as a primary product. This niter-cake is composed of say 70% to 78% free sulphuric acid. The new process, briefly stated, consists in dissolving the niter-cake in about its own weight of water and cooling the solution to —10° to —12° C. The bisulphate is decomposed; crystals of neutral sulphate of soda are formed, containing ten equivalents of water, which are separated in the solid state by a subsequent treatment in a centrifugal machine; the mother liquor containing the sulphuric acid (about 35° to 40° Baumé) which can be used in that state for the preparation of various sulphates, or can be concentrated to say 58° to 60° Baumé. One hundred parts of soda bisulphate yield from 120 to 130 parts of crystallized soda-sulphate with ten equivalents of water, and 40 to 50 parts of sulphuric acid concentrated to 48° or 50° Baumé.

The plant necessary for the treatment of materials as stated consists of tanks

for dissolving the bisulphate, one ice machine, and one centrifugal machine, as shown in Fig. 7. The cost of this plant is as follows, which does not include steam power:

To work 3,300 lbs. daily	$4,000
To work 6,650 lbs. daily	5,000
To work 12,000 lbs. daily	6,500

A working statement for the 12,000 lbs. plant would show the following:

Fuel	$2.50
Labor	10.00
Interest	2.00
Wear and tear	1.00
Total daily expense	$15.50

The returns from this plant would be 13,750 lbs. soda sulphate crystals and 4950 lbs. sulphuric acid, 48° to 50° Baumé. These returns are calculated on the

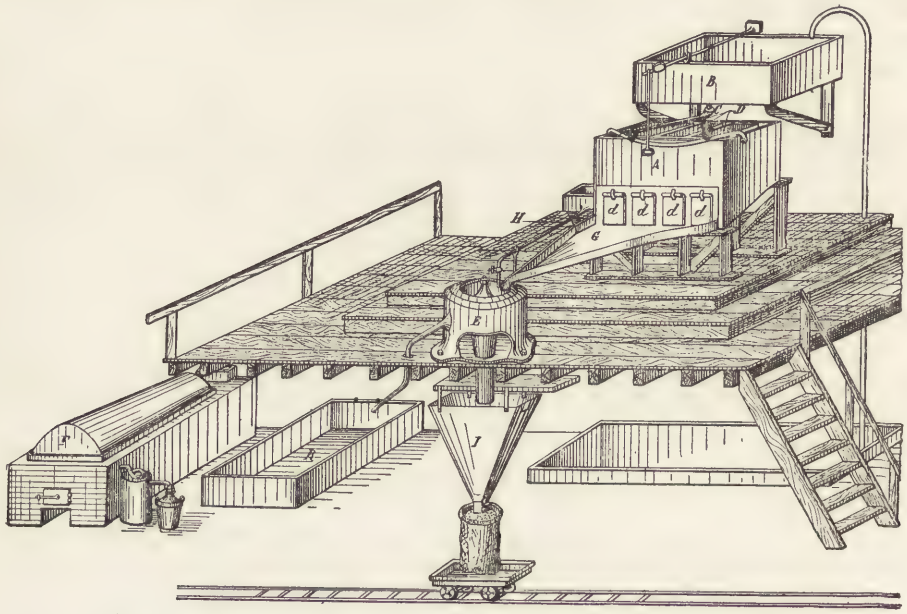


FIG. 7.—BARBIER'S PROCESS FOR TREATING BISULPHATE OF SODA.

actual products from the centrifugal and acid pans, and allow for a certain percentage carried in the mother liquors, for waste, etc. The values to be placed on the products as returned in this process are to be estimated with reference to the location of the plant, greater profit naturally accruing to plants located near to the points of consumption.

Another process (U. S. Patent No. 523,651) calls for a solution of niter-cake (24% to 28% of free acid) as a solvent for magnesite in the production of carbonic acid and a resultant pure alkaline sulphate. In this process 9300 lbs. niter-cake (with say 25% of free acid) is dissolved in 18,000 lbs. water to which is introduced 3000 lbs. of magnesite. Gently heating the mass disengages carbonic acid gas to the amount of say 1000 lbs., which comes over uniformly and regularly, being washed and utilized in the usual manner. After heating to boiling, and about the time all the gas is liberated, an alkaline reaction takes place, iron, aluminous and silicious matters being precipitated. The colorless solution contains soda sulphate and magnesium sulphate registering 36° to 38° Baumé.

CHROME IRON ORE.

METALLIC chromium does not occur in nature and is one of the rarer elements, being produced only in very small quantities and being more a curiosity belonging to the chemist's laboratory than a metal having any practical use. Although the metal itself is so rare, chromite, or chrome iron ore as it is most generally called, is found in many different parts of the world and in considerable quantities. This ore is a black or brownish black mineral of submetallic luster. In an approximately pure state it contains about 68% of chromic sesquioxide (Cr_2O_3) and 32% of ferric protoxide (FeO); part of the iron and chrome, however, are frequently replaced by magnesium or aluminum, so that chromite as found seldom contains over 50% of sesquioxide of chromite, and 50% is considered a remarkably pure ore.

Chromite is found in the United States chiefly in Pennsylvania, Maryland and California; the last named State now furnishes the chief supply.

The following table will show the production of chrome iron ore in the United States, the imports and the estimated consumption for the five years from 1890 to 1894, inclusive; the statistics for the years previous to 1890 will be found in THE MINERAL INDUSTRY, Vols. I. and II.

PRODUCTION AND IMPORT OF CHROME ORE IN THE UNITED STATES.

(In long tons of 2240 lbs.)

Year.	Production.			Import.			Consumption.	
	Quantity.	Value Per Ton.	Value.	Quantity.	Value Per Ton.	Value.	Quantity.	Value.
1890.....	3,599	$15.00	$53,985	4,353	$13.12	$57,111	7,952	$111,096
1891.....	1,372	15.00	20,580	4,560	23.85	108,764	5,932	129,344
1892.....	1,650	10.00	16,500	4,930	11.27	55,589	6,580	72,089
1893.....	1,629	9.84	16,000	6,354	9.23	58,629	7,984	74,629
1894.....	2,653	13.23	35,125	3,886	9.87	38,364	6,539	73,489

The chief use of chrome iron ore is in the chemical industry for the manufacture of potassium and sodium bichromates, for the preparation of basic furnace hearths, and for the manufacture of ferro-chromium, which is used in the making of chrome steel. Much the greater part of the mineral produced is em-

ployed in the chemical industry and for this purpose the best ores are required. In the manufacture of ferro-chromium the low grades of ore can be advantageously used. For furnace hearths chromite has now been largely supplanted by magnesite. The process of manufacturing potassium and sodium bichromates was very fully described in THE MINERAL INDUSTRY, Vol. II.

Outside of the United States chrome ore is found in Turkey, Greece, Norway and the Oural District in Russia; in Australia, New Zealand and New Caledonia. It is also found in Canada, in the Province of Quebec, where it has been mined to a small extent in the serpentine belt which runs through the eastern range of townships in that Province, extending from the Vermont line to the St. Lawrence.

In Central America chrome ore has also been found but never worked.

The most important deposit in the world, which is at present operated, is that at Brusa in Asiatic Turkey, which is noted for its great extent, the ease with which it is mined, its high grade, averaging from 52% to 57% of chromic oxide, and its freedom from silica, which is an objectionable impurity, and which is found in most of the Californian ores. Besides the Brusa Mines other large ore deposits are known to exist about 15 miles to the south of that town, and a third has been discovered near Antioch, but is not worked to any extent. Owing to its high grade and freedom from impurities the Turkish ore brings the best price.

Australia.—According to information furnished by Mr. E. Govett, Australia produced more chrome iron ore in 1894 than in any previous year, a great impetus having been given to the search for the mineral by the rise in price which took place about the beginning of the year. The principal source of supply is Gundagai in New South Wales, where chromite is found in serpentine rocks for a stretch of some 10 to 12 miles. The deposits, however, are very irregular both in quality and quantity, and this is the reason why no large company has been formed to mine for the mineral. The deposits are all worked by private parties, and the cost of raising, bagging and delivering the ore in Sydney varies from 26s. to 35s. per ton. With a London price of £5 per ton (2240 lbs.) for 50% ore, the price paid in Sydney is £3 12s. 6d., and 2s. 6d. per unit above 50%. The price near the close of 1894 was £3 5s. in Sydney. The purchasers in Sydney are usually shipowners or charterers who ship the ore as dead weight to wool cargoes. No ore under 50% is bought. Parcels have gone as high as 57%, but the average is 52% to 53%. About 500 tons of chrome a month were sent away from Gundagai during the greater part of 1894. The principal mine is known as Quilters, where there is still an enormous quantity in sight, though its grade has not been tested throughout. As a rule the smaller the deposit the richer the ore. Chromite is also reported to have been found near Orange, New South Wales, but none has been shipped. The reported great chromite discovery near Ipswich, in Queensland, turned out to have had no foundation in fact. Search has been made for chromite in the Barrier Range serpentine rocks but without result.

CLAY.

THE clay industry is one of those in which the different branches are so widely distributed, and find their material in so many localities, that it is difficult, or almost impossible, to obtain correct statistics. In some branches of the industry figures of production can be obtained, but in others a large part of the finished product is from small manufacturers and no exact records are kept. The consequence is that only estimates of the most general kind can be made, and any pretense of furnishing exact figures must be misleading, except in some special branches.

The subject of clay was very thoroughly treated in the article under that title in THE MINERAL INDUSTRY, Vol. II., and in the present number but little is to be added. During 1894 the clay industries generally were affected by the depression in business, and there was little or no increase of production, although the last quarter of the year showed a considerable improvement.

Brick Clays.—Manufactures of brick and its allied industries of drain pipe and tiles are the most important in amount and extent of all those which are based upon clay. The general conditions noted above apply with special force to this industry, nevertheless there has been some progress during the year, and some improvements have been made in the processes in use at different points. A notable fact is that very many manufacturers seem to have come to the conclusion that such improvements are necessary to meet the increasing competition of stone, and especially of iron and steel in the building trades. The result has been the formation of a number of associations and an increased activity in the management of the older organizations of this kind. Under this head may be mentioned such societies as the National Brick Association, the West Liverpool Pipe Manufacturers' Association, the National Association of Fire Brick Manufacturers, the Ohio Brick and Tile Association, the Indiana Tile, Brick and Drain Pipe Association, the Illinois Clay Producers' Association, and the Iowa Brick, Tile and Drainage Association. These societies are doing much good work by bringing the manufacturers together and promoting exchanges of views and experiences. They have also been of material assistance in promoting the application of technical knowledge among the manufacturers. Thus the practice of analyzing clays and of testing bricks and other works thoroughly is increasing very rapidly, mainly through the work of these

associations. In many cases the assistance of chemists and engineers can be secured through the association where the means of an individual producer would not enable him to secure such advice, and the results cannot fail to be useful.

The Iowa State University, through its engineering department, under the charge of Prof. Charles D. Jameson, working in connection with the State Geological Survey, some time ago undertook to make an examination of the clay resources of that State, which are of a widely varied character. Good progress has been made in this work, which promises to be of the greatest practical use.

As an example of the work done during 1894 in this direction, we give below a table showing the results of extended tests to determine the shrinkage of brick in burning and its relation to the composition of the article. These tests were made by Mr. Charles Ferry.

RELATION OF SHRINKAGE IN DRYING AND BURNING TO COMPOSITION OF BRICK.

Composition.		Length of Brick.			Shrinkage.	
Material.	Per Cent.	Pressed.	Dried.	Burned.	Total.	Per Cent.
		Inches.	Inches.	Inches.	Inches.	
1. Anhydrous kaolinite	97	9 7/16	9 3/8	8 3/8	1 1/16	15.5
Anhydrous silica	2					
2. Anhydrous kaolinite	88	9 7/16	9 1/16	8 1/2	0 15/16	10.0
Anhydrous silica	11					
3. Anhydrous kaolinite	79	9 7/16	9 5/32	8 5/8	0 13/16	9.0
Anhydrous silica	20					
4. Anhydrous kaolinite	70	9 7/16	9 1/8	8 3/4	0 11/16	7.5
Anhydrous silica	29					
5. Anhydrous kaolinite	61	9 7/16	9 5/32	8 7/8	0 9/16	6.0
Anhydrous silica	38					
6. Anhydrous kaolinite	52	9 7/16	9 3/16	9	0 7/16	4.5
Anhydrous silica	47					
7. Anhydrous kaolinite	43	9 7/16	9 7/32	9 1/8	0 5/16	3.5
Anhydrous silica	56					

In these tests the proportion of water varied from a trace up to 20%.

An industry which is growing in importance, especially in the West, is the manufacture of brick for paving purposes, and these articles are securing an extensive market in localities where suitable stone for road and pavements is scarce and has to be brought long distances. Much study has been given to the special qualities needed for a brick of this kind and a number of Western cities are giving them a test in practical use. There is no question as to the excellence of the roadway made, but their durability and consequently their real cost can only be determined by time, and there are very few instances where brick pavements have been laid long enough to fairly decide this question. The final determination will depend very much upon local circumstances.

An important branch of this industry is the manufacture of ornamental brick, or rather tiles, which has shown a very considerable growth in recent years, owing chiefly to the greater care taken in manufacture, and to the greater attention paid to designs. Many architects are finding these tiles useful, and are employing them in construction. Thus far this branch of the industry has had to meet the competition of cement tiles as well as of stone trimmings of various kinds, and prices have been necessarily kept very low in order to introduce the product. The use of iron construction in the cities and the introduction of

arched and hollow bricks for forming the floors and filling the spaces between the beams has furnished a considerable market for this form of tiles; and doubtless other applications will be found.

Terra cotta work is a branch of this manufacture and is growing steadily, though not rapidly in quantity and value of output.

For the reasons noted above the production of brick clay and clays of a similar class in the United States cannot be given with any pretense to accuracy, nor is it possible to give the total production of ordinary brick. In some detached districts, however, figures have been obtained which may help to give an idea of the progress of the industry.

In California the production of brick for all purposes is reported as 70,600,000 in 1893, and about 75,000,000 in 1894, and the industry is steadily growing.

The large demand for building brick from a rapidly growing city and an occurrence of deposits of clay of excellent quality have combined to locate in the vicinity of New York a very large brick industry. The centers of production are along the Hudson River on both sides, from just below Haverstraw on the south to the Highlands on the north, and beyond the Highlands from Newburg to Marlboro. Another important manufacturing center is found in Bergen County, New Jersey, in the clay deposits of the lower valley of the Hackensack. Reports collected from manufacturers in these districts give a total of about 900,000,000 bricks manufactured in 1893 and of 875,000,000 in 1894. The decrease in consumption was accompanied by a small increase in sales, since the stocks on hand at the close of 1894 were 39,250,000 less than at the close of 1893.

The industry in this district has suffered less from depression probably than in any other part of the country. Toward the close of 1894 there was a very decided increase in demand, and manufacturers generally reported a large number of orders on hand for the season of 1895. In this connection the following table, showing the prices of brick in New York for three years past, may be of interest as showing the general course of trade:

RANGE OF PRICES OF BUILDING BRICK PER THOUSAND AT NEW YORK.

Quality.	1892.	1893.	1894.
Pale	$1.75 to $2.00	$2.25 to $3.00	$2.00 to $2.25
New Jersey	4.50 to 5.00	5.00 to 5.50	4.50 to 5.50
North River	4.75 to 5.50	5.25 to 6.00	5.50 to 6.00
Croton Front	13.00 to 14.00	11.00 to 12.00	11.00 to 12.00
Philadelphia Front	23.00 to 24.00	22.00 to 24.00	22.00 to 24.00

There are some imports of brick in New York, though not a very large amount, as those brought from abroad are generally for special purposes and in comparatively limited number. Thus in 1894 the imports of common brick were only 834,720, which is a mere trifle compared with the amount of the production. The following table shows the imports and exports at the port of New York for five years, and we have also included in this statement the imports and exports of tile and fire-brick.

BRICK IMPORTED AND EXPORTED AT THE PORT OF NEW YORK.

Year.	Fire Brick.		Tiles (Pieces).		Common Brick.	Enameled Brick.
	Imports.	Exports.	Imports.	Exports.	Exports.	Imports.
1890	1,501,016	551,865	113,752	700	2,732,000	1,706,685
1891	968,639	563,500	81,754	2,323	1,467,500	957,505
1892	1,184,869	2,575,604	147,397	5,085	2,657,264	1,069,923
1893	1,492,110	1,378,898	166,236	2,750	2,757,520	1,362,400
1894	675,656	1,047,300	48,949	1,013	3,139,900	834,720

Fire-Clay.—The production of fire-clays or refractory clays is an industry of considerable extent and importance. Its principal centers at the present time are in New Jersey, Ohio and Missouri, although fire-clays are found at many other points.

The New Jersey producing district exists in a belt across the State from a point near the mouth of the Rahway River to the Delaware below Trenton. The principal points are Woodbridge, South Amboy and Sayreville, and in West Jersey between South Trenton and Bordentown. The best clays, however, are found in the vicinity of the Raritan River. The manufacture of fire-brick has been carried on there for many years successfully, and the industry of that district is the best established in the United States. The producing firms in New Jersey are over 50 in number, and the estimated amount of fire-clay taken out of the pits is about 30,000 tons yearly, although exact figures cannot be obtained. It is probable, however, that there will be an improvement in this respect hereafter, as the Fire Brick Association has appointed a special committee for the purpose of securing statistics of the trade; and this committee began work in 1894. The number of fire-brick made in New Jersey in 1894, including special shapes, is estimated at 50,000,000, which was about the same as in 1893.

The Ohio industry is of later growth. The fire-clays are generally found in connection with the coal measures. The production in Ohio was reported at 1,253,110 tons in 1892, but in 1893 there was a slight decrease and the total was 1,032,348 short tons. In 1894 it was estimated at 1,050,000 tons. Up to 1892 the production increased very rapidly, and in that year it was more than six times as great as in 1883.

The production of fire-clay in Missouri, according to official reports, was 245,149 short tons, valued at $193,849 in 1893. In 1894 there was but little change.

In northwestern Arkansas there are known to be large deposits of fire-clay and extensive brick works have been established at Fort Smith.

The total production of fire-clays and other refractory clays in the United States is estimated on the best obtainable information at 3,215,000 short tons in 1893 and 3,376,000 short tons in 1894.

Some fire-brick is imported and the amount received at New York, where nearly all the imports are made, is given in the table above. The following table shows the range of prices of ordinary fire-brick in New York for three years past:

COMPARATIVE PRICES OF FIRE-BRICK PER THOUSAND AT NEW YORK.

	1893.	1894.
Welsh	$25.00 to $25.50	$22.00 to $23.00
English	25.00 to 27.00	25.00 to 27.00
American No. 1	25.00 to 27.00	26.00 to 27.50
American No. 2	18.00 to 22.00	18.00 to 22.50

Kaolin and China Clay.—Kaolin is produced or prepared for market in Vermont, New Jersey, Delaware, Pennsylvania, North Carolina, Florida, Michigan and Ohio. The use of this clay in the pottery industry is well known. The principal consumption is, of course, in the pottery manufacturing centers, such as Trenton, N. J., and East Liverpool, Ohio, and the location of these industries is naturally determined to a large extent by the abundance of the output. In the New Jersey potteries the general tendency is to the manufacture of the finer grades of ware, while in Ohio ordinary earthenware, yellow ware and stone china are produced in large quantities, although fine ware is also made. In the East Liverpool district the value of the production has reached a considerable figure, amounting to over $2,000,000 annually.

The North Carolina deposits have not been extensively worked as yet. Samples of kaolin from Florida have been pronounced of most excellent quality, and the deposits are said to be large, but they have not as yet furnished any considerable commercial supply.

The production of kaolin in the United States in 1894 is estimated at 24,552 short tons, a decrease of 5631 tons from 1893. At the close of the last named year, however, there were considerable stocks on hand which were sold or used during 1894.

Missouri Clays.—The following information is furnished by Dr. Charles R. Keyes, State Geologist. Missouri is unusually well supplied with exhaustless quantities of good clays suitable for the manufacture of nearly all grades of clay products, from the ordinary common building brick to chinaware. For common and ornamental brick, the lees and residual clays are used largely, producing an excellent grade of material. The shales of the coal measures furnish an excellent grade of material for sewer and pottery; also for common ornamental, building and paving brick. There are large deposits of kaolin and china clays which are now being developed.

New York Clays.—The following notes on the clay industries of New York have been supplied by Mr. F. J. H. Merrill: Perhaps the most important group of mineral industries in New York is that of the clay products, including brick, tile, terra cotta, sewer pipe, etc. The brick manufacturing interests are chiefly dependent upon the quaternary clays of the Hudson River valley and various other parts of New York. On Long Island the clays of cretaceous and tertiary age are to some extent used in the manufacture of brick. Within a few years a new industry has developed in the use of Silurian and Devonian shale as a substitute for clay in the manufacture of paving-brick, terra cotta and various other clay products. The cretaceous clays of Staten Island afford material for an industry in fire-brick and refractory ware. At many other places in New York these products are manufactured, but not from clays produced within the

State. The refractory clays of Long Island and the feldspar of Weschester County are entirely used in the manufacture of stoneware and other pottery at Trenton, N. J. The receipts from the various branches of the clay industry in New York for the year 1892 aggregated nearly $9,000,000. Since that time no accurate census has been taken.

Feldspar.

This mineral, technically known as orthoclase, or potash-feldspar, is quite abundant and is found in many localities, but there are comparatively few places where the quality and the extent of the beds give them a commercial value. The chief sources of the production at present are the quarries at South Glastonbury, Conn., and along the Brandywine River in the extreme southeastern corner of Pennsylvania, and across the line in the State of Delaware. Quarries were also worked formerly near Bath and Edgecombe, Me., at Haddam, Conn., and at Peekskill, N. Y. A deposit of feldspar was formerly worked extensively in the neighborhood of Old Bedford and Poundridge in Westchester County, New York. These quarries have not been operated for several years, but recently a new discovery was made not far from the last-named village, near the Connecticut line, which is said to be of large extent.

A small quantity of feldspar is used in the manufacture of some kinds of glass, but its principal use is as an ingredient in certain kinds of china and as a glaze for china. The consumption, which varies from 15,000 to 20,000 short tons yearly, is almost entirely in the pottery manufactures.

COAL.

By Frederick Hobart.

In the article on this subject in The Mineral Industry, Vol. II., the general position and divisions of the coal-bearing territory of the United States were carefully outlined. In the present paper we may briefly recapitulate that the coal fields are divided primarily into anthracite and bituminous. The former furnishes from a comparatively limited area over one-fourth of the total supply of the country, while the latter cover an enormous area, estimated in total to be nearly 300,000 square miles. The bituminous coal areas may be subdivided into seven great fields, of varying extent and importance, as follows: 1. Appalachian, including the great coal belt extending through western Pennsylvania, Ohio, Maryland, the two Virginias, Kentucky, Tennessee, Georgia and Alabama, including about 64,500 square miles of area. 2. The Triassic, covering a comparatively limited area of less than 3,000 square miles in North Carolina and Virginia. 3. The Northern field, also a comparatively limited one, in Michigan. 4. The Central coal field, including Indiana, Illinois and western Kentucky, about 47,250 square miles in all. 5. The Western coal field, the largest of all, covering roughly nearly 99,000 square miles, and extending through Nebraska, Iowa, Missouri, Kansas, Arkansas, the Indian Territory and Texas. 6. The Rocky Mountain field, including the coals of Dakota, Montana, Idaho, Wyoming, Utah, Colorado and New Mexico. 7. The Pacific Coast coal field of Washington, Oregon and California. The extent of the Rocky Mountain and Pacific coal beds is hardly yet defined.

Of these fields the Western has the largest area, while the Appalachian field is at present by far the most important, partly because it produces the best qualities of bituminous coal now mined, and partly because its exploitation was begun at an earlier date and has been carried out on a much greater scale.

The Triassic field, although a part of it, in Virginia, was the first developed in this country, is of limited extent and importance, furnishing at the present date but a small fraction of the total supply.

The Northern field, in Michigan, has never been of much importance, and the total output has been very small, partly owing to the fact that the beds are much broken by barren areas and are poor and difficult to work.

The Rocky Mountain field is as yet but little developed, but presents many possibilities for the future, and the same may be said, though in a lesser degree, of the carboniferous area of the Pacific coast.

The following table shows the production of coal and coke in the United States by States for 1893 and 1894, with the approximate values of the product at the mines in both years:

TOTAL PRODUCTION OF COAL AND COKE IN THE UNITED STATES.

(In tons of 2000 lbs.)

States.	Coal.					
	1893.			1894.		
	Tons.	Value.	Value Per Ton.	Tons.	Value.	Value Per Ton.
Bituminous—						
Alabama	5,170,042	$4,911,540	$0.95	4,381,295	$3,943,165	$0.90
Arkansas	725,000	890,250	1.25	*f* 672,866	799,919	1.20
California	75,000	175,500	2.34	94,754	236,885	2.50
Colorado	3,786,232	5,452,174	1.44	2,862,994	3,521,483	1.23
Georgia	372,191	338,694	.91	354,111	300,994	.85
Illinois	19,949,564	17,954,608	.90	*f* 17,113,576	15,402,218	.90
Indiana	*f* 4,583,000	4,528,830	1.01	*f* 3,065,394	2,973,432	.97
Indian Territory	1,229,562	1,844,343	1.50	1,072,542	1,662,440	1.55
Iowa	*f* 3,790,000	4,699,600	1.24	*f* 3,776,373	4,720,466	1.25
Kansas	2,881,930	3,688,870	1.28	2,701,191	3,241,439	1.20
Kentucky	3,302,250	2,872,958	.87	2,967,195	2,521,615	.85
Maryland	3,327,749	2,899,142	.87	3,101,982	2,729,744	.88
Michigan	22,072	32,887	1.49	.....	.....	.....
Missouri	*f* 3,190,442	3,541,391	1.11	*f* 2,383,322	2,740,820	1.15
Montana	783,300	1,660,596	2.12	688,780	1,377,560	2.00
New Mexico	457,085	713,052	1.56	323,721	485.581	1.50
North Carolina	17,000	25,000	1.50	13,150	20,514	1.56
North Dakota	*e* 125,000	125,000	1.00	*e* 150,000	165,000	1.10
Ohio	14,828.097	13,197,006	.89	11,902,678	10,117,276	.85
Oregon	41,478	103,695	2.50	42,509	95,645	2.25
Pennsylvania	43,421,898	36,474,394	.84	41,867,188	29,307,033	.70
Tennessee	1,857,432	1,485,945	.80	2,589,664	2,019,938	.78
Texas	322,745	645,490	2.00	469,904	1,000,895	2.13
Utah	421,400	632,100	1.50	453,601	635,041	1.40
Virginia	842,933	673,835	.80	925,837	694,378	.75
West Virginia	*f* 9,838,011	7,575,268	.77	*f* 10,559,926	7,401,948	.70
Washington	1,211,550	3,610,420	2.98	1,183,660	2,840,784	2.40
Wyoming	2,243,401	3,118,327	1.39	2,224,135	2,869,134	1.29
Other States	10,000	21,400	2.14	8,000	17,120	2.13
Total bituminous	128,826,364	$123,892,315	$0.96	117,950.348	$103,842,467	$0.88
Anthracite—						
Arkansas	15,000	52,500	3.50	50,994	178.479	3.50
Colorado	160,000	482,472	3.00	131,034	366,897	2.80
Pennsylvania	47,179,563	74,070,913	1.57	51,828,405	80,334,028	1.55
Total anthracite	47,354,563	$74,605,885	$1.58	52,010,433	80,879,404	$1.55
Total coal	176,180,927	198,498,200	.....	169,960,781	184,721,871	.....

States.	Coke.					
	1893.			1894.		
	Tons.	Value.	Value Per Ton.	Tons.	Value.	Value Per Ton.
Alabama	1,064,902	$1,810,333	$1.70	924,002	$1,524,603	$1.65
Colorado	345,500	777,375	2.25	283.945	562,211	1.98
Georgia	90,726	150,705	1.66	86,000	136.740	1.59
Illinois	2,100	3,465	1.65	2,400	3,960	1.65
Indiana	4,926	9,212	1.87	4,500	7,785	1.73
Indian Territory	7,000	16,170	2.31	7,131	16,900	2.37
Kansas	8,500	17,595	2.07	7,500	14,850	1.98
Kentucky	46,147	74,758	1.62	27,715	44,067	1.59
Montana	33,000	99,000	3.00	30,000	86,100	2.87
New Mexico	7,684	18,288	2.38	6,706	15,490	2.31
Ohio	21,345	35,006	1.64	15,000	23,850	1.59
Pennsylvania	5,549,297	8,767,889	1.58	5,561.476	7,952,910	1.43
Tennessee	247,049	380,455	1.54	316,358	477,700	1.51
Utah	305,622	705,987	2.31	29,286	64,429	2.20
Virginia	119,321	183,754	1.54	117,800	174,344	1.48
West Virginia	1,075,862	1,613,793	1.50	1,067,157	1,526,034	1.43
Washington	6,780	33,561	4.95	4,294	14.213	3.31
Wyoming	4,200	9,198	2.19	4.025	8,372	2.08
Total coke	8,939,961	14,706,544	$1.65	8,495,295	12,854,558	$1.49

(*e*) Estimated. (*f*) Fiscal year.

The results presented in this table are certainly a surprise. A year ago when the figures for 1893 were made up it was a matter of astonishment that the output of coal in the United States during a year more than half of which was a period of panic and depression, should have nearly equaled that of any previous year on record, and now, in making the statistics of production for 1894, we find that although the complaints of hard times and its accompaniments of closed industries and decreased demand continued very nearly the whole year, there was, as compared with 1893, an actual increase in the output of anthracite coal of 4,655,870 tons, or 9.8%, while in bituminous coal the total reduction was only 10,876,016 tons, or 8.5%; so that the net decrease in total output was only 6,220,146 tons, or 3.5%.

This result is still more surprising when we remember that for two months the production of coal from a large part of the most important mining districts in the country was interrupted by one of the most extensive and obstinate strikes known in the history of the trade. It is to this strike, and the consequent diminution in supplies for the time being, that the increase in the anthracite production is mainly to be attributed. The absolute dependence of nearly all of the great industries upon steam and fuel in some form makes the coal trade the best indication of their growth or decrease, and the fact that a total loss of only 3½% in the production of fuel was the result of the year would seem to indicate that the great depression and dullness of some prominent industries in 1894 was offset by a steady growth in other lines. It may also be considered as an indication that the surplus production upon which the condition of industry depends is usually very small, much smaller than is generally supposed.

The prices realized for coal at the mines were extremely low. In 1893 the average for bituminous coal had fallen a little below $1 to 96c. per ton, but in 1894 there was a further reduction of over 8%, and the average price was 88c. per ton at the mines. This very low price, without doubt, had an effect in increasing the output, for in many industries the low cost of fuel certainly had an important part in deciding the possibility of continuing at work, and it helped the manufacturers in many directions to meet the lower prices for goods which prevailed in all the markets. The lower prices also served to keep up the domestic demand, which, though necessarily small in individual cases, has in the aggregate an important influence upon the trade.

These remarks must be understood as applying chiefly to the bituminous coal production. The anthracite trade is conducted under peculiar conditions, and we find that not only was the production increased but prices were very nearly the same, the average value at the mines showing a decrease of less than 2%. The anthracite production, owing to the limited area of the fields, is controlled by a few companies, while the peculiar qualities of the fuel command a special market which is less liable to interference than that taking bituminous coal.

The production of anthracite coal in Arkansas and Colorado is exceedingly small compared with that of Pennsylvania, and is sufficient only to meet a local demand. It can hardly be considered as affecting in any way the general result.

The conditions of the anthracite production are fully considered in the article on the "Anthracite Coal Market" given below. The following table shows the United States production of coal for the five years from 1890 to 1894 inclusive;

the statistics for the years prior to 1890 will be found in THE MINERAL INDUSTRY, Vols. I. and II. In nearly all the important coal-producing States reports are issued by the mine inspectors which cover the different districts very fully and treat them in much greater detail than is possible in a yearly review covering the entire country.

UNITED STATES PRODUCTION OF COAL, 1890–1894. (IN SHORT TONS.)

Year.	Alabama.	Arkansas	California.	Colorado.	Georgia	Illinois.	Indiana.	Indian Territory	Iowa.	Kansas.
1890.....	4,090,409	399,888	110,711	3,075,781	228,000	15,274,727	3,305,737	869,229	4,021,739	2,516,054
1891.....	4,759,781	542,379	93,301	3,512,632	171,000	15,660,698	2,973,474	1,091,032	3,825,495	2,753,724
1892.....	5,314,227	739,300	131,431	3,771,234	165,000	17,949,989	4,494,811	1,004,765	3,820,000	2,794,000
1893.....	5,170,042	740,000	75,000	3,946,232	372,191	19,949,564	*f*4,583,000	1,229,562	*f*3,790,000	2,881,930
1894.....	4,381,295	*f*723,860	94,754	2,994,028	354,111	*f*17,113,576	*f*3,065,394	1,072,542	*f*3,776,373	2,701,191

Year.	Kentucky	Maryland	Michigan.	Missouri.	Montana.	New Mexico.	North Carolina.	North Dakota.	Ohio.	Oregon.
1890.....	2,483,144	3,357,813	74,977	2,437,399	517,477	375,777	.....	.....	13,203,522	61,514
1891.....	2,916,069	3,820,239	80,307	2,650,018	541,861	462,328	.....	.....	14,616,209	51,826
1892.....	3,020,050	3,036,283	70,000	3,017,285	648,701	434,291	.....	.....	14,599,908	34,720
1893.....	3,302,250	3,327,749	22,072	*f*3,190,442	783,300	457,085	17,000	*e*125,000	14,828,097	41,478
1894.....	2,967,195	3,101,982	.....	*f*2,383,322	688,780	323,721	13,150	*e*150,000	11,902,678	42,509

Year.	Pennsylvania.		Tennessee.	Texas.	Utah.	Virginia.	West Virginia.	Washington.	Wyoming	Total.
	Bituminous.	Anthracite.								
1890.....	42,302,173	46,468,640	2,429,935	184,440	318,159	784,011	6,002,800	1,263,689	1,870,366	156,073,611
1891.....	42,788,490	50,665,431	2,703,319	172,100	371,045	736,399	8,155,201	1,056,249	2,327,841	169,543,948
1892.....	46,576,576	52,472,504	2,413,678	300,000	363,020	800,000	8,710,878	1,000,000	2,454,449	180,399,217
1893.....	43,421,898	47,179,563	1,857,432	322,745	421,400	842,933	*f*9,838,011	1,211,550	2,243,401	176,180,927
1894.....	41,867,188	51,828,405	2,589,664	469,904	453,601	925,837	*f*10,559,936	1,183,660	2,224,185	169,960,781

(*e*) Estimated. (*f*) Fiscal year.

Review of the Coal Trade.—The history of the bituminous coal trade in 1894 is memorable for two things—the long and extensive strike which interrupted production, and the sharpest competition and lowest prices on record. The great strike, which was chiefly the result of reductions in wages in various quarters, made on account of the depressed trade and low prices, was ordered by a convention of miners held at Columbus, Ohio, early in April, and was begun on the 21st of that month. Practically the movement was not in operation until May 1st, but the orders of the convention were very generally carried out, and for a time there was an almost complete stoppage of coal mining, extending from the Cumberland region on the east to the Missouri River, while the miners of Colorado and Wyoming to a large extent joined in the movement. On the eastern boundary of the Appalachian region, in the Cumberland and Clearfield districts, it was not so complete as it was through Ohio, Indiana and western Pennsylvania, nevertheless there was sufficient trouble to seriously reduce the output. The strike lasted for nearly two months in spite of various efforts to put a stop to it. Neither the miners nor operators were able to call it a victory, and it finally came to an end through a compromise which was adopted by a conference of miners and operators held at Columbus in the middle of June. Some local disturbances continued to exist, but in the end the compromise was

very generally adopted, and by the middle of July the coal mines were again in operation. The anthracite trade was not affected by the general strike and, as we have noted before, the anthracite operators profited considerably by the scarcity of bituminous coal which was caused by the movement.

The coal trade has always been peculiarly liable to labor disturbances, but no more extensive or more obstinate strike has ever occurred in this country ; it can only be compared with the great English strike of 1893, which reduced the output of the British coal mines by nearly one-fourth for that year.

The other marked feature of the trade in 1894 was the excessively low prices obtained for coal and the competition for business. As our table shows above, the average value of coal at the mines was less by 8% in 1894 than in 1893, while in many cases the reduction at the final market was even greater, owing to lower rates of freight and other causes. Part of this competition was due to a decrease in the demand and to a very general disposition to keep mines at work by making concessions to consumers, but part was also due to a condition of affairs which had been maturing for years. The extension of railroads and the opening of new fields have brought new supplies into the market, and some of them have been pushed forward without any regard to existing interests, as indeed was to be expected from the new competition for business.

The conditions of the bituminous coal trade may perhaps be better understood from a brief general description of the producing districts and their markets. Necessarily this must be given in very general terms and without too strict a division. In doing this also it will be understood that we disregard altogether the anthracite trade, which has a field peculiarly its own, and which comes in competition with the bituminous producers to a comparatively limited extent.

The bituminous trade of the Eastern seaboard is—or was until within a few years—supplied almost entirely from the mines of central Pennsylvania and Maryland, and especially from the districts locally known as the Clearfield, Beech Creek, and Broad Top Mountain in Pennsylvania; the Cumberland in Maryland, and Elk Garden in West Virginia. Western Pennsylvania is divided into two producing districts. The northern district finds its market in the cities of central New York, in the trade from the Lake Erie ports to the upper lakes, and also to a considerable extent in the Canadian cities. The southwestern Pennsylvania, or Pittsburg district, which is the oldest, most thoroughly worked and the largest producer among all the bituminous coal regions, supplies the extensive demand of the local manufacturers and iron works, and until recent years controlled almost exclusively the coal business of the cities along the Ohio River, and on the Mississippi below the mouth of the Ohio. Of late years the coal operators of the Kanawha and New Rivers, West Virginia, and of Kentucky, have furnished an increasing part of the supplies of the river cities.

The coal mines of Ohio not only supply local demands and those of the manufacturing cities on the south shore of Lake Erie, but also contribute a considerable amount for shipment to the upper lakes, the coal from the Hocking and Tuscarawas Valleys finding its market as far west as Chicago. The Indiana coals compete chiefly with those of Ohio, although they are largely of a somewhat lower grade, and only the block coal from the Brazil district finds a ready market where Hocking Valley coal can be obtained.

The Illinois mines fill the local demand, and the mines of the central and northern portions of the State ship large quantities to Chicago. Those of the southern section supply St. Louis and the adjoining districts. The coal of Kentucky has heretofore sought sale chiefly to the northward; it has been carried as far as Chicago within recent years, but cannot yet be said to constitute an important element either in the local or the lake trade of that city. Thus far no State west of the Mississippi has furnished coal in sufficient amount to become a serious competitor for business beyond its own borders; while the Pacific Coast States do not yet produce enough for their own use.

The States south of Kentucky and east of the Mississippi still consume most of the coal which they produce, but some Alabama coal is sent to the seaports for steamer use and for export to Mexico, the West Indies and South America.

The first changes in the long-established order of the trade were due to the introduction of Kanawha coal to the tidewater markets by the Chesapeake & Ohio Railroad, and to the opening of the Beech Creek mines in Pennsylvania. The Kanawha coal was a disturbing element for a time, but its competition was not pushed as closely as it might have been, for various reasons. The Beech Creek region has placed its output more in central New York and western New England than on the seaboard.

We have purposely left until the last a region which has been in great part responsible for the increased keenness of competition in recent years. This is the Pocahontas district in southwestern Virginia and in the southern part of West Virginia, which had long been known to contain abundant supplies of coal of excellent quality, but was first made accessible some nine or ten years ago by the construction of the branches and extensions of the Norfork & Western Railroad. That railroad and its connections have brought the Flat Top and Pocahontas coals into both the Eastern and Western markets with the result of disturbing both alike. With a railroad haul to Norfolk of 428 miles, which is longer than most of the competing districts, this district has nevertheless managed to secure a large share of the business, but in doing so has brought about a permanent reduction in price. In the tidewater markets Pocahontas has proved a successful rival to the Clearfield and Cumberland coals as a steam coal, especially for ship use, while in the West it is carried not only to the Ohio River but as far as Chicago. Part of this success has been due to the excellent quality of the coal itself, but a greater part to keen business management and to the cooperation of the railroad in granting rates which counterbalanced the effect of the longer haul.

The competition for trade has brought about prices which would have seemed almost incredible a few years ago. A brief history of the course of events in this district will illustrate the course of the trade for several years past. The organization of the coal region served by the Norfolk & Western Railroad, has been from the beginning very complete. The whole of their trade has been in the hands of a single company through which all business with the railroad and with customers was transacted. In 1886, when the Pocahontas Coal Company came into existence and took charge of the trade, a contract was made with the producing companies which provided that 75c. per ton should be the minimum

price paid for "run-of-mine" coal at the mines, but a year later, when the miners' strike occurred, the price was increased to 85c. per ton in order to permit an increase of wages. However, when other districts commenced to reduce their prices to meet those of the new producers, a supplementary agreement was made by which the coal operators agreed to sell the coal required for fuel to the Norfolk & Western Railroad and 300,000 tons for the New York harbor trade at 75c., while coal for the line and local and the Western trades still remained at 85c. This concession continued in force for some years, but during that time the growth of the line and Western trade had the effect of raising the price received by the operators from an average of 81½c. per long ton in 1888 to 83¼c. in 1893. In the spring of 1894 the full effect of depressed business was felt, and the company, claiming that a reduction was necessary, made an offer of 70c. per ton for all "run-of-mine" coal, at the same time making a condition that there should be no reduction in miners' wages. This proposition the operators united in refusing, and after some discussion and an unsuccessful attempt at arbitration, a compromise was accepted whereby the operators received 72½c. for "run-of-mine"—practically for screened coal, for all the fine coal is used to make coke. This may seem low enough and yet since the close of 1894 the rate has been reduced to 65c. per ton. It must be remembered that the operators in the Flat Top and Pocahontas fields are nearly all working under leases and are required to pay a royalty of 10c. per ton, leaving an average of not more than 55c. per long ton out of which wages and all expenses of working must be paid. Moreover there are some minor exactions, such as a reduction from mine weights for waste, and a charge of 1c. per ton for inspection, still further reducing the price. It is hardly to be wondered at that an attempt has been made to cut wages and that it has recently caused a strike in this region, which in large part escaped from the general strike of 1894. There is some confusion as to the results obtained by the operators; on the one hand it is claimed that even the extremely low price named leaves them a surplus; on the other many of them say that they are working below cost and must depend for a living upon the company stores and other subordinate sources of income.

The total reduction has not by any means, however, been borne by the operators in this case, the railroad also having reduced its prices. It is well known that coal has been sold f. o. b. Norfolk at $1.85 per ton, and this would have left less than ¼c. per ton-mile for railroad freights.

While this is an extreme case, there are other districts in which business has followed a very similar course, and others also in which the case has been harder, owing to greater costs and difficulty in mining coal.

At the time of the tariff discussions in Congress during the spring and summer a great deal was said about the possibility of the importation of Nova Scotia coal; we did not at that time believe that such importations were to be feared, owing to the inferior quality of the coal and the fact that it could not compete in price—when its efficiency was considered—with our own coal. An excellent opportunity for the introduction of this fuel on the market was provided during the strike in the summer of 1894 when there was, for a short time, a scarcity of coal in the Eastern markets. It does not appear that this opportunity was taken. A small amount of Cape Breton coal was sold in the New England

ports, but imports were not continued, and it was evident that even under exceptionally favorable conditions nothing was to be feared by our own miners from the competition of the Canadian coal pits.

The opening of new fields and the increase of production has gone faster than the demand for consumption, and the result is that at present, and probably for years to come, the coal business must be conducted under circumstances which will require the most rigorous economy, the best management and the liberal use of machinery to enable operators and miners alike to make a living profit.

The World's Production.—The table given below shows the world's production of coal for the five years from 1890 to 1894 inclusive; the statistics for the years prior to 1890 will be found in THE MINERAL INDUSTRY, Vols. I. and II.

COAL PRODUCTION OF THE WORLD. (IN METRIC TONS.)

Year.	Africa	Australasia.					Austria-Hungary.	Belgium.	Canada.		France.	Germany.
		New South Wales.	New Zealand.	Queensland.	Tasmania	Victoria.			Alberta, British Columbia	N. Brunsw'k, Nova Scotia.		
1890	99,791	3,110,157	647,659	343,791	51,332	24,852	27,504,030	20,365,960	820,087	2,023,167	26,083,118	89,291,834
1891	156,603	4,102,940	679,562	275,949	43,952	29,625	28,822,439	19,675,664	1,195,665	2,077,605	26,024,893	94,252,278
1892	250,000	3,841,842	684,155	269,354	36,243	30,445	29,225,004	19,583,173	1,006,721	1,974,059	26,178,073	92,544,050
1893	300,000	3,330,939	691,548	268,260	43,893	93,202	26,548,604	19,407,251	925,298	2,556,085	25,738,073	95,476,208
1894	600,000	.....	.....	.....	.....	.....	.....	20,458,800	1,327,259	2,168,340	27,459,137	98,876,105

Year.	India.	Italy.	Japan.	Russia.	Spain.	Sweden	United Kingdom	United States.	All Other Countries	Total.
1890..	2,203,434	376,326	2,650,277	6,007,457	1,238,395	187,512	184,538,278	141,589,980	3,973,563	513,130,000
1891..	2,366,067	289,286	3,226,975	6,233,025	1,320,139	198,033	188,465,340	153,810,270	1,854,690	535,101,000
1892..	2,578,299	295,713	3,199,763	6,325,020	1,461,196	199,380	184,713,640	163,657,988	1,500,000	539,554,118
1893..	2,570,332	317,249	3,328,879	6,560,320	1,531,810	199,933	166,971,440	159,919,176	1,500,000	518,456,180
1894..	.....	.....	.....	7,498,000	1,776,000	.....	188,277,525	154,229,383	1,600,000	.....

A review of the table shows that Great Britain continues to lead as a coal producer; the loss of 18,000,000 tons shown in 1893 was due to a long strike which extended through the more important districts in that year. The output of 1894 reached very nearly to the high-water mark recorded in 1891, which is the most prosperous year ever recorded in the British coal trade. Great Britain continues to be the one country in the world which produces an enormous surplus of coal for export; other countries ship coal abroad but on a comparatively limited scale. Upon the whole, however, this export trade is not increasing; while no other country has so many customers for fuel, local competition continues to increase in various parts of the world. Thus in the East, British trade has suffered severely from competition with Japanese coal, which has found its way, through the shrewdness and energy of the Japanese exporters, into all the Eastern ports, and has been sold extensively, not only for local use but as steam coal for vessels. Japan has no coal so far developed which is equivalent for steam purposes to the best Cardiff, but when quality and price are both taken into account it becomes far more economical and cheaper than British coal in all the Eastern ports, and now with the possession of Formosa, Japan becomes a still more formidable rival. Similar attacks on British trade have been made in other quarters, and for many years past some British steamers

have made their best time in crossing the Atlantic when burning Pocahontas and other American coals.

The coal output of other European countries shows a comparatively steady growth, with fewer fluctuations than have been apparent in the British trade. In 1893 France, like England, suffered from labor troubles, with the result of reducing the coal output, but the loss was more than made up in 1894. Germany has shown a remarkably steady growth and at the present rate will in another year pass the line of 100,000,000 tons yearly output. This amount includes lignite, which forms nearly one-fourth of the total and which has a much less fuel value than the ordinary coal. No new fields have been discovered or opened either in Germany or in France, and the geological resources of both countries have been so carefully investigated that it is doubtful whether any notable discoveries of this kind will be made. France is not an exporting country; a small quantity is sent to Belgium from the districts adjoining the frontier, but this is more than offset by the imports which are required to supply the home demand. Germany likewise exports some coal to Belgium, Austria, and France, but imports nearly as much as she exports and sends little or no coal to any countries outside of Europe.

Austria-Hungary, which is the third producing country in Europe, has more opportunity for development than either France or Germany, since its coal fields have been but partially explored. The Hungarian and Transylvanian coal fields in particular are susceptible of considerable extension in production whenever the demand shall require it. In Austria, however, about one-third of the total production is made up of lignite.

In Belgium the coal production has apparently reached very nearly its possible maximum, many of the workings having attained to so great a depth that their continuance, even should the shafts reach new veins of coal, will hardly be profitable as long as supplies are obtainable from abroad, and the chances seem to be that the production will not increase, though it may still hold its own for some years. The active industries of the country cause Belgium to be an importer of fuel as well as a large producer.

The coal area of Italy is very limited and there is little opportunity for an increase of its production. In Sweden, likewise, the coal-bearing area is small and the production nearly stationary. The Spanish mines are capable of considerable development, but the production will not increase materially until manufacturing becomes a more important interest in the country. Holland, Portugal, Denmark, Norway and Greece do not produce mineral fuel in any commercial quantities.

Russia is the only one of the European countries which is known to possess great reserves of fuel. The present output of the country comes chiefly from the mines of Poland and the great Donetz basin, the other coal fields having thus far been comparatively little worked. That their exploitation will be extended as the demand for coal increases there is no doubt. In European Russia coal is known to exist in the thinly settled sections bordering on the White and Arctic Seas, and there are also extensive coal fields in the Volga basin and in the Caucasus. They remain unworked partly from lack of transportation and partly because the demand is not sufficient to warrant their opening. As the

manufacturing interests of Russia increase, and as the forests in the eastern and northern parts of European Russia, which still supply local demands for domestic fuel, gradually disappear, the working of the coal mines will be extended. Already in the treeless areas of Southern Russia the demand is largely met by the crude oil or refuse oil from the wells of the Apsheron peninsula, simply because the coal mines are not accessible owing to the lack of railroad connections or the long distances over which the heavier fuel must be hauled. The greatest fuel resources, however, which Russia possesses are found in the Siberian territory. Further reference is made to this subject in the article on "Russia" in the present volume, but we may add that these coal deposits are not yet of commercial importance and will not be until they are supplied with proper transportation. In Asiatic Russia some coal has also been found in the Trans-Caspian territory which will be eventually of very great commercial and military importance to Russia.

In Australasia the financial overturn of 1893 affected the coal trade even more than the other commercial industries and all the colonies show a decrease in output, which was further accentuated in 1894, as far as our information extends. New South Wales is the most important producer of the Australasian colonies and the only one which has any considerable surplus for export. Australian coal is found in most of the Pacific ports and some of it is sent to California. In the East, however, it has suffered from the competition of Japan. New Zealand has some surplus for export, but sends it chiefly to the Australian mainland. The other colonies do not produce enough to supply their own necessities. It must be remembered that Australia has from the beginning depended largely upon mineral fuel; the greater part of the Australian continent is a treeless country, and only in Tasmania and New Zealand is it possible to rely upon wood as a fuel to any extent.

In the Asiatic countries we have already referred to the enterprise of Japan in pushing the sale of its coal, and it is hardly necessary to note that the production of that country is increasing rapidly. Japan has a considerable area of carboniferous territory and its production can be considerably increased without fear of exhaustion.

British India is increasing its output steadily, though not rapidly. Already a very considerable part of the railroads of India use native fuel, although the coal of India is not usually of the best quality; the cost of importing coal from England is very great by comparison with that of the local coal. Besides those already worked, extensive fields are known to exist in central India, in northern India and in Burma, which are as yet hardly touched, so that the time may come when this country will be an important feature in the world's supply.

China reports no coal. A little is mined in the Woosung coal field, but it is impossible to ascertain its actual amount. While the coal-bearing area of China is believed to be very great, little or nothing is known definitely about it. The changes that are expected to follow the recent war and the promised opening of the country, have some effect upon the working of these fields.

The estimated coal production of Africa was nearly doubled last year. A small part of the increase was from the working of mines in Algiers and Tunis, but by far the greater part came from the opening of new mines and the

enlargement of old ones in Natal and the Transvaal, and was due to the rapid increase in the demand for coal by the mining interests of South Africa. From present indications this demand will increase, and already the Transvaal companies have made arrangements to extend their workings, while those of Natal and the northern edge of Cape Colony are securing railroad connections which will give them a share of the business. The Transvaal coal is of good quality, making a fair steam coal, though it is claimed not equal to the Natal coal which is found nearer the coast. Outcroppings of coal have been reported to some extent in the northern part of Mashonaland and in the Zambesi country, but have not yet been explored.

From the figures given we may estimate the total production of coal in the world in 1894 at 540,000,000 tons.

Coke.

But little change is to be noted for the year 1894 in the production of coke or the methods employed in its preparation. The coke trade is so intimately connected with the iron manufacture that the output cannot be expected to increase while the iron and steel industries are suffering from depression and limited demand; and the year under review presented no exception to the general rule.

While the production did not show any gain in 1894, as compared with 1893, there was a very small loss, and the output shown in our tables was very nearly the same in both years. The light production of the early months of the year was made up partly by the demand arising from the rapidly increasing activity of the iron furnaces during the later months, and partly by the policy adopted by some of the great iron companies of the Pittsburg district of accumulating very large stocks of coke to provide against a possible shortage from labor troubles.

The Connellsville district in southwestern Pennsylvania continued to be the great coke-producing region, and from our tables it will be seen that Pennsylvania furnished 66% of the total supply. Some progress was made elsewhere, especially in West Virginia, and coke from that State made its appearance in Chicago and other Western markets, where it has gained a foothold and promises to become an important rival of the Connellsville product, especially for foundry use that requires the highest quality. The temporary scarcity of the latter, caused by the strike in May and June, offered the West Virginia producers, whose mines and ovens continued at work, an opportunity of which they were not slow to take advantage.

As in the coal trade the year was marked by extremely low prices. For a considerable time Connellsville coke sold at $1 per short ton on cars at the ovens, and several times the price broke to 90c., once or twice even to 85c. The year closed with a slight improvement.

The Alabama coke producers have continued to supply the local market, but have not extended their trade. The Southern coke-makers are gradually introducing improvements, chiefly in the way of washing and preparing the raw coal before sending it to the ovens. Wherever such changes have been made the results have been so good as to encourage further work in this direction.

The low prices of coke, which is apparently to be permanent, owing to the increasing competition and the entrance into the market of new producers, have

led to much discussion as to methods of reducing costs of production. The coke-makers still adhere almost universally to the old beehive type of oven, which furnishes a good coke, but does not utilize the gases, tar and other products of the coal. The future of the trade seems to depend upon the introduction of some of the improved types of ovens which have already become universal in Europe. In Germany and Belgium especially, it has been proved that by the use of by-product saving ovens—such, for instance, as the Semet-Solvay, the Otto, and the Simon-Carves—the by-products obtained from the coal are sufficient in value not only to pay a handsome profit on the increased cost of the plant, but to cover substantially the cost of operation; while the quality of the coke is stated to be fully equal to that made by the old methods.

At the Havre Colliery in Belgium, the results obtained in practice with 25 ovens of the Semet-Solvay pattern were, in brief, as follows: The first cost of each oven, with a capacity of 100 tons of coke per month, was greater by $608 than that of an ordinary oven. The additional cost of labor was very small; the total cost per ton of coke was 28c., or about 6c. more than under the old system. The value of the by-products, after deducting all other extra charges, was 36c. per ton of coke. The net gain was therefore 30c. per ton from this system, or $30 per oven per month, this amount being very nearly 5% a month, or 57% a year on the additional cost of the plant.

In France the trial of an arrangement for utilizing the gases from the coke ovens to heat the boilers furnishing steam for the colliery has been so successful that it is being introduced at Epinac, Dourges, and several other leading collieries. This arrangement depends for its practicability upon local circumstances.

In this country general attention has frequently been called to the urgent need of improved methods, but so far little progress has been made in their practical application. A plant of the Otto type has been nearly completed for the Cambria Iron Company, but it was not at work in 1894. A thorough investigation is being made for another company, which will probably result in the erection of a large plant; and there is little doubt that the next two or three years will witness important changes in the coke industry.

One result of the intimate connection between the coke trade and the iron industry has been that no systematic search has been made for a wider market, and very few attempts have been made to extend sales in other directions. At intervals some endeavors have been made to introduce crushed coke for household use, usually in the Western cities. It has there come into competition with anthracite coal, and so far the results have not been such as to encourage the makers to continue these attempts. As coke-making extends with the introduction of improved methods, and new districts come into the market, it is altogether probable that new efforts will be made in the direction named, and it would seem that a considerable demand might be created for this fuel, which is far more cleanly and convenient for household purposes than the ordinary bituminous coal, and which could probably be supplied at a reasonable price in many places where the cost of transportation makes anthracite a luxury.

The Anthracite Coal Market in 1894.

The course of the anthracite coal market in 1894 was eventful but not cheerful. The year 1893 was not one of the most profitable in the history of the trade, and it established the record in the matter of production. The hard times which afflicted more or less severely almost every other industry made an exception in favor of the anthracite coal trade, and in October, at a time when the monetary stringency was at its worst, the shipments amounted to 4,525,663 tons—the heaviest single month's shipments recorded up to that date.

Naturally the effect of the heavy tonnage during the second half of 1893 was to render next to impossible an active demand in the early months of 1894. The "hard times" did not intend to miss the anthracite trade altogether; they had been slow in coming, and that was all. It was pointed out in the *Engineering and Mining Journal* at the time that cautious and conservative action must govern the course of the anthracite interests if the trade was to escape the disastrous experiences which had overtaken other industries. Consumers were well supplied, and the necessity of a radical restriction in the output was early recognized. In no other way could fair prices be maintained. The production began to decrease; still, so great was the dullness of the trade that prices also declined steadily. In June the real demoralization of the trade began, and aided and abetted by the producers it grew until it reached a point more critical than it has touched for years, worse than the ante-McLeod times. June 1 found the anthracite shipments for the preceding five months—even with the May figures of 3,793,303 tons, which was more than should have been mined—2,991,923 behind the shipments during the corresponding period of 1893. Had the companies adhered to the tonnage recommended by the sales-agents, the market would have been 5,600,000 tons behind 1893's output for the first five months, and producers would have been able to mine with impunity what they later mined to their detriment.

It sounds paradoxical to say the very thing which should have been beneficial to the trade really proved its undoing. The trouble began with the soft coal strike. Railroads, and other consumers of bituminous, being unable to get their usual fuel, began to buy steam sizes of anthracite. The anthracite interests had given their elastic words to restrict the June output to 60% of the October, 1893, tonnage, or to 2,800,000 tons, and also that each company would adhere to its "allotment." May prices were also advanced, avowedly for the purpose of frightening customers into buying supplies. An era of harmony and good sense was to rule during the balance of the year. It so happened, however, that only a favored few had secured new business of any consequence during the latter part of May, and to fill these orders they had to mine considerably in excess of their allotment. Perhaps harmony could have been preserved by turning over to less fortunate competitors some of the extra orders. The less fortunate competitors refused to sit idly and simply mine their share of the 2,800,000 tons "recommended" by the sales-agents as the output for June. Wisdom counseled moderation. But the counsel was unheeded. The "official" June prices not only never obtained, but even May prices were "shaded" in order to book orders which called for delivery in October and September, and perhaps even later. The upshot of it all was that June shipments aggregated 5,112,359 tons—the

heaviest single month's tonnage in the history of the trade, beating the previous "best record" (October, 1893) by 586,693 tons. This, too, in a year in which conservative estimates proved the market would take 4,000,000 tons less than 1893.

From that time on the history of the course of the market may be summed up in one word—overproduction. And the inevitable consequence was weak and ever declining prices. In September and October the weakness was the greatest, and net prices for free burning stove coal on board were $3.10 to $3.30. Even in the last week of November most of the companies were willing to sell stove coal at $3.25 on board.

There is no "combine" or "trust" in the anthracite coal trade, no illegal "pool." There is merely an "understanding among gentlemen." The various interests are bound by nothing stronger than their word as gentlemen. The sales-agents meet once a month, and after more or less discussion of the trade and of what its welfare—from a producer's standpoint—demands, they make what they call fair prices—a "circular," which is sent to customers—and they "recommend" to their superiors that the output for the month under discussion should be restricted to a tonnage which the market can be trusted to take during that time. The absurdity of "recommending" monthly outputs may be tabulated as follows:

Month.	Tonage Recommended by Sales-Agents. Tons.	Actual Tonage. Tons.	Excess Tons.
January	2,250,000 (a)	2,622,808	372,808
February	2,250,000	2,291,472	141,472
March	2,250,000	2,495,058	245,058
April	1,800,000	2,757,306	957,306
May	2,800,000 (b)	3,793,303	993,303
June	2,800,000 (b)	5,112,359	2,312,352
July	2,800,000 (b)	3,868,216	1,068,246
August	2,500,000	3,089,844	589,844
September	2,500,000	3,270,612	770,612
October	3,000,000	4,136,859	1,136,859
November	Ad libitum. (c)	4,493,281	.....
December	2,550,000	3,105,190	555,190

(a) The "recommendation" was first 2,500,000, but in a spasm of good sense it was later changed to one-half of the October, 1893, output. (b) The "recommendation" was really 60% of the October, 1893, output, or only 2,715,398 tons, but we are generous. (c) This was the crowning piece of folly. For some reason or other the agent did not or could not agree upon an output for November, and decided to let everybody mine as much as was necessary, although the use of moderation and common-sense was to be exercised. Naturally, if producers had adhered to the "recommendations" the total amount mined would not have been sufficient. But if the agents had seen that their advice was heeded by their superiors they would have "recommended" larger tonnages than they did in the second half of the year. What it is wished to emphasize is that the much-discussed "recommendations" have been most carefully unheeded.

The above table shows that there was an apparent desire to limit the output within safe bounds but an actual inability to do so.

The Bureau of Anthracite Statistics reports that total shipments were 40,448-336 tons in 1891, 41,893,316 tons in 1892, 43,089,536 tons in 1893, and 41,391,-200 tons in 1894, or 1,698,336 tons less than in 1893. Including the amount consumed at the mines, the total production of anthracite during the year amounted to 43,874,672 tons, as against 45,674,909 in 1893. The increase over the preceding year was thus 1,444,980 tons in 1892 and 1,196,220 tons in 1893; or, say, an average of more than one and one-quarter million tons. Had normal times prevailed, this would have brought shipments in 1894 to 44,240,000 tons in round numbers, instead of showing a decrease of 1,698,336 tons as compared with 1893. If we take the normal increase in consideration, the theoretical decrease was more

than 3,000,000 tons. At an average of $3.30 per ton at tidewater, there is thus an actual decrease of more than $6,000,000 in business in 1894, or, if normal times had prevailed, of more than $10,000,000.

In January prices for good free-burning coal, on board, net, were $4.15 to $4.30 for stove and chestnut, $3.70 to $3.85 for egg, and $3.50 to $3.60 for broken. A period of great dullness followed, and by May prices had declined from 25c. to 50c. a ton. Then came the period of great folly, and in September prices were: $3.30 to $3.50 for stove; $3.25 to $3.40 for chestnut; $3.25 to $3.35 for egg, and $3.10 to $3.25 for broken. Certain "off grades" of coal could be bought for less.

In mid-November prices were: $3.20 to $3.30 for stove; $3 to $3.25 for chestnut; $3.10 to $3.25 for egg, and $3 to $3.20 for broken. Then came a series of meetings of the presidents and much discussion, and meetings of the sales-agents and considerable talk, and prices were advanced to $3.60 for stove, $3.45 for egg and chestnut, and $3.35 for broken, net, on board. The market closed dull, with an extremely small demand, and the sales-agents of the companies were able to maintain these prices because nobody wanted any coal at any price. Certain individual operators and some middlemen who had bought coal at low prices continued to underbid the companies by 10c. or 15c.

Since the organization of the Anthracite Coal Operators' Association, the individual or "independent" operators—that is to say, the owners or workers of collieries not controlled by a railroad—have been heard of at various times. These operators number about 100, and their aggregate tonnage is about one-fourth of the entire production. Those individuals, located along the line of the Lehigh Valley Railroad, after much squabbling and discussion, finally secured the same terms that they had under the Reading regime, namely, 60% of the tidewater price; that is, if the price for which coal was selling at tidewater was $3.50 per ton, the Lehigh Valley paid the operator $2.10 at the mine for his coal. In October and November the companies were, with one shining exception, cutting the tidewater prices, and yet at those "line points," where there was no competition, each company was getting much higher prices. The operators had the pleasure of selling their coal to the company at $1.90, because that was 60% of the tidewater price, and the company sold it at non-competitive points for much more. On Nov. 17 a Committee from the Board of Managers of the Anthracite Coal Operators' Association, representing the shippers along the Lehigh Valley Railroad, requested the Lehigh Valley Coal Company to "meet the market and sell their coal at the best price obtainable at any and all points, in order that line and tidewater price might be more in harmony." On the same date Coxe Brothers & Co. announced that they had decided to give to manufacturers and dealers the benefit of New York prices, and would quote shipments to interior and line points at the mine at a price equivalent to the New York price, less the freight rate to tide. Later, Coxe Brothers, on account of the death of Mr. E. B. Ely, did not push their determination, and the Lehigh Valley compromised with the operators by raising the tidewater prices.

The year closed with a better feeling prevailing, Prices were maintained, and the presidents met and resolved to take steps to prevent the recurrence of the actions which made 1894 so poor a year. The weather during the fall was decidedly against the seller, however, largely reducing sales.

The Interior Coal Markets in 1894.

Buffalo.—Aside from its position as a local distributing point for a number of large towns and villages, and from the consumption of its own factories, tugs and fleet of lake craft, the chief importance of Buffalo in the coal trade is as a shipping point for coal going to the upper lakes. Formerly a considerable share of the anthracite coal went to Buffalo by canal, but in recent years this traffic has somewhat decreased, and nearly all the anthracite delivered in Buffalo, either for consumption or shipment, is received over the railroad lines. Buffalo is also connected with the coal-producing region of western Pennsylvania by several railroad lines, and is thus an important coal port. The statistics collected by William Thurstone, secretary of the Merchants' Exchange of Buffalo, show that the coal trade of Buffalo was as follows, in tons of 2000 lbs.:

	1891.	1892.	1893.	1894.
Receipts—				
Anthracite by canal	.....	54,760	70,546	42,130
Anthracite by rail	4,507,804	4,750,000	4,700,000	4,230,000
Bituminous by rail	2,428,084	2,652,441	2,921,614	2,305,470
Total receipts	6,935,888	7,457,201	7,692,160	6,577,600
Shipments—				
Bituminous by canal	34,060	29,316	19,336	8,840
Anthracite by lake	2,358,895	2,822,330	2,681,173	2,475,255
Bituminous by lake	7,000	30,000	22,500	10,000
Total shipments	2,399,955	2,881,646	2,723,009	2,494,095

The largest amount of coal shipped to any one point for the season of 1894 was 1,119,187 tons to Chicago. Milwaukee came next with 557,264 tons; while 242,606 tons were sent to Duluth, and 198,254 tons to West Superior. The remainder was distributed to various ports on Lake Huron and Lake Superior. The range of freight charges on coal during the year 1894 from Buffalo was: To Chicago and Milwaukee, 25c.@70c.; to Duluth and Lake Superior ports, 15c.@35c.; to Green Bay, 40c.@50c.; to Toledo and Detroit, 25c.; to Racine, 30c.@75c.; to Saginaw, 35c.@40c.; and to Bay City, 25c.@40c.; all per net ton.

Pittsburg.—The river coal trade, which chiefly affects the Pittsburg market, was not very prosperous during 1894, although it remained very nearly at the level of 1892 and 1893. It still showed a considerable decrease from the average of the five years from 1885 to 1890, and was 40% below the high-level mark which was reached in 1888, when shipments of 109,852,000 bushels were sent down the Ohio. In 1893, for the six months from May to November, one-half the year, no shipments of coal were made from Pittsburg by river, owing to dry weather and the low water in the Ohio. This not only left the lower markets open to the competition of other fields, but at the same time entailed a large expense on the coal shippers, whose tugs and barges were lying idle.

The river shipments from Pittsburg for 13 years past have been as follows, in tons of 2000 lbs.:

Year.	Cincinnati.	Louisville.	Total.	Year.	Cincinnati.	Louisville.	Total.
1882	1,378,480	1,467,160	2,845,640	1889	1,214,400	1,515,800	2,730,200
1883	1,261,320	2,258,480	3,519,800	1890	1,304,640	2,042,160	3,346,800
1884	985,240	1,232,040	2,217,280	1891	1,125,000	1,931,600	3,056,600
1885	1,303,600	1,693,360	2,996,960	1892	973,560	1,549,960	2,523,520
1886	1,329,160	1,537,406	2,866,568	1893	879,950	1,617,840	2,497,790
1887	830,800	1,438,920	2,269,720	1894	1,139,920	1,383,280	2,523,200
1888	2,053,560	2,340,520	4,394,080				

The Coal Mines in Wyoming.

By Wilbur C. Knight.

The actual tonnage of coal mined in the State of Wyoming in the year 1894 was slightly less than in 1893. This was chiefly due to the greatly reduced production of Uinta County, caused by the closing of No. 7 mine on account of fire, and the shut-down at Nos. 5 and 6 for six weeks. Sweetwater and Carbon Counties also show a slight decline in output. On the other hand, the central counties and the northern and eastern sections all show an increased production. Crook County, which has until recently been only a local producer, has been added to the list of coal mines under the jurisdiction of the coal-mine inspector. A very important discovery was made during 1894 by Mr. J. D. Curtise of Ham's Fork. The coal found is, so far as it has been tested, the best yet known in the State, for either steaming or domestic purposes. The output of the Wyoming coal mines, by counties, for the year 1894, was as follows, in tons of 2000 lbs.:

Name of County.	Local Mines.	Shipping Mines	Total Output.	Value.
Sweetwater	.....	1,287,704	1,287,704	$1,467,882
Weston	.....	331,560	331,560	497,340
Carbon	1,300*	323,408	324,708	412,038
Uinta	.....	145,213	145,213	262,670
Converse	.....	82,900	82,900	130,192
Sheridan	4,000*	31,850	35,850	59,569
Johnson	7,200*	.....	7,200	18,000
Crook	600*	4,500*	5,100	7,650
Fremont	2,700*	.....	2,700	7,150
Albany	1,200*	.....	1,200	2,400
Total	17,000	2,207,135	2,224,135	$2,864,891

*Not reported by the coal inspector.

Coke produced by the Cambria mines for 1894, was 4025 tons, valued at $14,087.50.

The Coal Fields.—The coal fields of Wyoming can best be described by referring them to three great divisions—the southern, the central, and the northern, which will include the major portion of the productive measures; following this description by that of the numerous smaller independent coal basins.

The southern coal field occupies a stretch of country along the southern boundary of the State, extending from the central part of Albany County, westward to the State line, and including the coal mines at Alma, Rock Springs, Black Butte, Hanna and Carbon, and a score or more of local banks. From the central part of Albany County this field has a general western course, but also widens, diminishes, and branches out, having a very irregular boundary line on the north and south. In Carbon County its southern limit is just north of Elk Mountain, and its northern the Freezeout Hills. The width there remains about the same as far west as the Platte River, where the field branches, the northern limit flanking the Seminoe Mountains and extending westward toward Red Desert; the southern passing between Fort Steele and Rankin, gradually emerging into the great basin west of the Rawlins uplift. This basin, with its northern boundary the northern limit of the Red Desert, and its southern the Colo-

rado line, extends westward to the Green River, and includes the greater part of Sweetwater County. The coal measures west of Green River are badly folded and broken, and the once large field has been cut up into several small ones. The leading coal basins are as follows: Henry's Fork, Alma, Ham's Fork, Twin Creek and Cokeville. The entire area within the limits described is not coal-bearing, for the formation has been disturbed by folds, as at Como and Fort Steele; by erosion, as in the valley of Rock Creek; by uplifts, like the one east of Rock Springs, and eruptive agencies, as in the Leucite Hills. These barren localities are very small when compared with the total extent of the field, and would not cover 10% of its area. A considerable extent of the field in Sweetwater County is overlaid by eocene rocks, which may, owing to their thickness, prevent coal mining within that area until the cost of such work in the West is greatly reduced.

The central field extends across the central portion of the State, between the Big Horn Mountains and the Rattlesnake Hills. Its eastern boundary is in Converse County, passing north and east from the town of Douglas into Weston County, and south and west to the Laramie Mountains. The southern boundary follows the Laramie Mountains westward to within a few miles of Casper, where it turns abruptly to the north for a few miles, and then westward, following the trend of the Rattlesnake Hills to the junction of the Little and Big Popo Agie rivers. The northern boundary has not been carefully traced out. In some places this field joins the southern extension of the great field on the north, as in Johnson County. Westward from the plains country the northern limit of the field conforms to the foothills of the southern end of the Big Horn Mountains, and then has a northwest trend to the Shoshone Indian reservation. The western boundary of this great coal basin is on the reservation, but has not been established. This field, unlike the southern, has not been greatly disturbed by faulting, folding or upheavals, and there is no evidence of eruptive rocks cutting through the formation. There is, however, a considerable area covered with Tertiary lime and sandstone.

The northern field includes all of the coal measures of Sheridan and Johnson Counties, a large proportion of Crook County, and some of Weston. The Big Horn Mountains form the western boundary of this field, and the Montana line the northern in Wyoming, for this great basin extends for miles into Montana. Seven-tenths of Sheridan County is underlaid with coal, and the field extends eastward into Crook County to the Belle Fourche River. South of Crook and Sheridan Counties the field covers the greater part of eastern Johnson and the northwestern corner of Weston County. This basin has been somewhat tilted by the elevation of the Big Horn Mountains, but has not been faulted or folded to any extent, and has not been covered with later rocks. The surface, however, presents a remarkable appearance, which in many instances has been confused with that resulting from volcanic action. The surface veins have been consumed by fire and the intense heat has melted the rocks above and often caused them to flow. The whole country, especially in the northern and central parts, presents a reddish hue, due to the burning of the coal beds.

While these three great fields include most of the coal measures of the State, there are several important localities outside their limits. There is a field of con-

siderable size in the northeastern corner of the State, extending from Cambria northward to the State line, and varying in width from 5 to 15 miles. In Natrona County, between the Rattlesnake uplift and the Sweetwater Hills, there is a small field having a width of a few miles and an unknown length. In Big Horn County, on the west side of the Big Horn River and north of the Owl Creek Mountains, there is a large basin, the limits of which are not definitely known. Coal has been found at many places between Owl Creek and the Stinking-water River, and it is quite probable that this field when traced out will prove to be one of considerable size. In northern Uinta County there is a large tract of undeveloped coal land between the Gros Ventre River and the Buffalo Fork of the Snake River, which has its eastern boundary just west of Union Pass, and the western at Jackson's Hole. There are also some narrow basins of coal land between the southern field in Uinta County and the Gros Ventre. A small basin also exists at the head of the Little Medicine River, partly in Albany and partly in Carbon County. Coal has also been found in Goshen Hole, and a few miles southwest of Cheyenne in Laramie County, but on account of the inferior quality of the fuel no estimate has ever been made of these localities.

The following table will give the productive area of the Wyoming coal fields. This estimate has been carefully made, and only workable measures have been considered. It also gives the number of mines in each county and the approximate thickness of the coal veins :

Name of County.	Area in Sq. Miles.	No. of Shipping Mines.	No. of Local Mines.	Thickness of Coal Veins, Ft.
Sweetwater	3,313	10	.....	4 to 12
Carbon	2,421	3	3	6 " 31
Crook	2,360	1	3	5 " 7
Fremont	2,242	.....	3	4 " 7
Uinta	2,000	3	.....	7 " 75
Big Horn	1,820	.....	.....	5 " ..
Converse	1,612	2	1	4 " 6
Sheridan	1,524	2	3	6 " 16
Weston	1,208	2	.....	5 " 7
Johnson	1,320	.....	3	4 " 7
Natrona	1,247	.....	2	4 " 17
Albany	400	.....	3	4 " 6
Total	21,464	23	21	.....

Geological Horizon of the Coal Measures.—The Wyoming coal fields are cretaceous, but not all of the Laramie group. Within a few years it has been found that the Dakota group, the Bear River group (at one time thought to be Laramie, but, according to T. W. Stanton, below the Colorado group) and the Montana group are coal-bearing, and probably the Colorado also. While the rocks of the cretaceous period, therefore, can truly be called the Western coal measures, the greater part of the coal area of the State belongs to the Laramie group.

Quality of Coal.—The coal mined can be classified as follows: Bituminous—coking and non-coking—semi-bituminous, and lignite. Although there are several veins of coal in the State that will form coke, the Cambria mines are the only ones which produce coke of commercial importance. The bituminous coal is generally an excellent fuel for both domestic and manufacturing purposes. It

contains very little water and a small percentage of ash. It is quite hard, having a bright fracture, and can be transported any distance without great loss by crushing and shrinkage. The semi-bituminous coal has a much higher percentage of water and slacks more readily. It is used for steam fuel, and is also sold extensively during the winter months for domestic purposes. The lignite coal has a high proportion of water, often reaching 20%. Upon exposure to the warm atmosphere it cracks and crumbles, and soon falls to pieces. This class of coal can only be transported successfully during cold weather. It is used for domestic purposes and firing stationary boilers, but, as far as tests have proven, cannot be recommended for locomotive use, as the small particles of burning coal are so light that they pass the screens of the stack and cause great damage by fire.

Mines and Development.—The coal industry in Wyoming started with the incoming of the transcontinental railway. Since that day it has grown to be the greatest industry of the State. The mines are as a rule worked through slopes varying from 3° to 26°, 7° being a fair average. The thickness of the coal veins ranges from 3 ft. to 75 ft.; those less than 3 ft. are considered valueless. The average thickness of the veins mined is above 6 ft. As a rule the mines are not troubled with gas. The only ones in which fire damp occurs in sufficient quantities to cause serious results are at Alma and Red Cañon, in Uinta County. The greatest development is found along the Union Pacific Railroad, since coal was mined there for 15 years before the other fields in the State were opened. Rock Springs has the greatest number of mines, and by far the greatest output. It also has the largest mines in the State. The main slopes of the Union Pacific Coal Company's No. 1 and No. 3 mines are over a mile in length, and from the east to the west face of No. 3 mine the distance is over two miles. The next largest mines in the State are at Cambria, in Weston County. The mines are generally equipped with modern machinery and worked by modern methods, compressed air and electricity being used to operate mining machines and drills. Electric haulage has been in successful operation at Rock Springs for several years.

Fuel Value of Wyoming Coals.—Acting upon a suggestion given in THE MINERAL INDUSTRY, Vol. I., p. 106, the University of Wyoming has made analyses and determinations of heating power of the most important coals of Wyoming. The calorimetric determinations were made by Professors Slosson and Colburn with Mahler's bomb calorimeter. The proximate analyses were made by Professor Knight. The results of these proximate analyses and calorimetric tests are given in a special bulletin issued by the University. An average of 54 determinations, made on coal from 43 different localities, shows the following results: Calories per gram, 6282; foot-lbs. per lb. of coal, 8,779,000; water at 212° F. evaporated by 1 lb. coal, 11.70 lbs.

The Economics of Coal Mining.

By William Nelson Page.

Quality and cost, supply and demand may be considered relatively as covering the entire subject. The first is determined by nature, the last two by fixed laws of trade, but cost is very largely dependent upon individual effort and skill. Given natural facilities and market, the cost will be in direct proportion to intelligent direction. Labor, therefore, is the single unknown quantity. Co-operation is possible between intelligence and ignorance, brain and muscle, between capital and labor, and this seems the solution upon which the future must depend and for which the conditions are now ripe. Heretofore demand and profits have been large, and when labor was reduced it found an escape in free government lands, while there was a market for all that land could produce; but since the farm as well as the mine, and all other channels for labor, are over-produced there is no such escape at present, and the two interests are brought face to face in every industry. Under such conditions capital must be satisfied with smaller dividends, labor with reduced wages, and both must harmonize for constant employment.

Much has been done in the way of cheapening coal production by machinery and other economies; but much remains to be done in the application of common sense and scientific knowledge to the individual mine, by which the laborer as well as the capitalist will be benefited. There is too much labor wasted in following the example of some other mine or district where the coals or local conditions may be slightly different. Two mines, apparently alike, may be worked in such a way as to produce the same output with uneven expenditure of labor. Every coal measure possesses an individuality, and each mine some characteristics which may be general over large areas, but there are local peculiarities which are often very limited. These affect the cost materially, and are rarely recognized first by the miner who performs the labor.

The cost of mining coal, and delivery at pit, or drift mouth, may be divided into two parts, which are often nearly equal in bituminous mines above water level. One is the digging price paid the miner, which is a fixed, or contract price, determined by the scales, or measure. The other, denominated "dead work," is composed of many and all other items embracing labor, machinery and material. Tracks, haulage, ventilation, timbering, dumping, supervision, and many other items enter into this half, for which the labor is usually paid per day. Intelligent direction of this portion, therefore, is more directly in the interest of capital than of the laborer, whose compensation is measured by time instead of task; consequently more attention is paid to economy in these details than to the digging price, which the miners often fix through their organization, and attempt to make common over entire districts, independently of the labor to be exercised upon the ton, which is very often different, owing to variations in thickness, laminations, slates, partings, and other conditions which should not be overlooked by the digger or operator in arriving at the minimum cost. In nearly every district where one digging price prevails, there may be found mines where the same measure of labor will produce nearly twice as much as in others. Such inequalities always operate against the miner when competition becomes

close, for he must either dig the unprofitable coal at a loss, or submit to a system of taxation, or rebate, in rents and store. The "pluck-me store" is a dishonest imposition upon capital as well as labor, and is employed largely as a means of reduction, where the organized miners would resist an open and honest reduction in wages. In many instances the books will show a loss on mining, with sufficient profits on rents and store to make the business satisfactory to the operator. Legislation is beginning to press measures against such company stores, but there is danger in prohibition, since some are operated for the protection of labor, under conditions where combinations might be formed to put up prices; it is very difficult to legalize any middle course. It must be admitted, however, that such cases are few, though when conducted in the interest of labor the store becomes a very important factor in its cost, and its abolition would take from capital one of the best means for reconciling labor to necessary reductions, by reducing its cost of living at the same time.

What has been said may be briefly illustrated by taking the actual history of a particular mine. This mine was opened and operated for a time by a strong English corporation, under English management. The company paid the miner 65c. per ton, run of mine, and sold the coal at $1, later at 80c. f. o. b. at mine. Losing money on this basis, the mine was leased to a coöperative association of practical and experienced miners, who had about $30,000 paid-up capital. They began operations with an unlimited market at 80c., paid the digger 60c. and day labor the prevailing prices. The organization consisted of a secretary, treasurer, and general manager, all of whom were governed by the majority, each member having one vote. Weekly meetings were held for the purpose of instructing the officers upon details, and the miners were largely in the majority when the inevitable conflict came. After a year it was found that they were losing money, but still had about $20,000 in the treasury. Wages had to be reduced, and factions became hopelessly divided. The miners wanted to reduce the day men, and maintain their 60c. per ton; the day men and officers insisted that the reduction should be pro-rated among all. The result was a scramble for the $20,000 in sight, and the majority vote reduced the day men and raised the digging to $1 per ton, which of course broke up the association, and it was said by all that the officers kept the money. The mine was next leased to an experienced American (since a most successful operator), who employed many of the association members, paying 60c. for mining and receiving 80c. After a year or two this operator and his labor were bankrupt, and abandoned the property. The English owners then took the mine in hand again, under competent and intelligent management. After a careful study of all the details, it was found that the mine had been worked upon the wrong system, based upon custom and drainage, rather than upon the peculiarities of the coal and roof. Where deep undercuts and explosives had formerly been necessary, it was found by experiment that under a different system the coal would come down on a 12-in. cut without powder or shearing. Thus formerly one man could load what two could dig, but with the changes one man could dig what two could load. The miners were offered 35c., which they accepted upon condition that prices be reduced in the store, and in less then two months they admitted that they were making more than ever before. This price was maintained for four years with profit to all, and the same

has been true during the last five years upon a digging price of 25c. per ton. Such individualities may be found, to some extent, in every mine, and unless the miner is properly directed a large part of his labor may be wasted.

The time is at hand when we can no longer afford to waste the volatile hydrocarbons in the manufacture of coke, since the by-products may frequently be worth more than the coal. If these were saved both labor and capital might receive additional compensation, and it is a waste which capital alone can utilize. The responsibility for this extravagance has for some time past been due to the consumer, who declines to pay the full value for the coke because it is made by a new—to him—process, and is slightly altered in appearance. Old prejudices must be laid aside; capital and labor, the producer and consumer, must be brought closer together upon lines of common interest to get the most economical results.

In overproduction the survival of the fittest should depend upon the natural and healthy order, rather than upon the forced and artificial conditions, which, as applied to mining, have been largely produced by the policy of our railway systems in the attempt to force developments along their lines. When a railway corporation attempts to equalize every mine on its line by discriminations in the markets and car supplies, it is taking upon itself a burden which will eventually weight it down by overproduction and competition. No overproduction can be healthy, and it is a mistake to divide one man's work among two when there is a possible way to avoid the necessity. There are few coal-carrying roads at present that will provide market or transportation facilities for a single mine sufficient for its most economical working. Such conditions result in enforced idleness and loss to both labor and capital, and consequently in an increased cost and lower rates to the road.

A division of profits has been tried, and will succeed as long as there are any profits to divide, but must fail when losses are involved, as labor is not content with less than standard wages as a basis, and can never make good any share of loss. There are instances, however, where profit-sharing has worked successfully for a number of years, but in such cases it will be found that the business and markets had been thoroughly established, and that little or no loss has been involved.

Machine mining is coming into general use, not so much for its saving in direct cost as for the indirect economy in having to control a fewer number of men for the same output. It is a weapon with which to meet organized skilled labor and their unreasonable demands. When the coal is difficult to cut, and the pick very expensive, the machine undoubtedly effects a direct saving; but it is largely used now where such is not the case, and pick-mining might be done as cheaply but for the miners' unions and their attempts to control pick-digging. As the machine does the mining, the proportion of skilled labor is largely reduced, and the result is found in less belligerence and conflict; a sufficient inducement though the direct costs be the same. In the Hocking Valley, Ohio, the machine has been found very profitable, though there is little saving in the calculated cost.

Just as Connellsville has been copied in coke manufacturing throughout the country, without taking into consideration chemical and physical conditions, so

in coal, one plan or system has been almost universally followed in mining, probably for no better reason, in many cases, than familiarity with an established custom. Since weight is a very important factor in mining, affecting the miner as directly as the "sand blast" does the excavator of rock or dirt, it is evident that the system should be adopted which will enable the miner to utilize this natural force to the greatest advantage consistent with other conditions. Of all the systems employed, "long-wall" admits the greatest utilization of weight, yet it is rarely used in this country, though almost universally employed in Europe. In addition to the saving that might be effected through the miner in this respect, there are other direct considerations, such as roof, haulways, etc., that are well worth more careful attention than has been generally accorded the subject, and which must be expected from the intelligence of capital and not from the laborer. As a rule the mine is entrusted to a "bank boss," or mine superintendent, who, having been a coal digger, is relied upon as a practical miner, upon the assumption that experience has taught him the whole subject. Such an assumption is a grave mistake. The fact that he has been a miner is evidence that his hands have been educated rather than his head; and there is no class of men more set in fixed grooves, or less liable to make changes, than the practical miner. Put such a man in conjunction with a scientific expert, and the best results may be expected. Each is valuable in his line, but neither can accomplish the desired object alone. It is a typical case of practice *versus* theory, in which the practice is very often wrong, and theory may as often be impracticable. Laying aside all theories for the reconciliation of labor and capital, as a practical fact they are members of one body, and as mutually dependent as body and mind. The former must sustain and renew the latter, and the latter must direct, protect and govern the former. As the brain has multiplied hand-power through the lever and other mechanical devices, so must capital multiply the power of labor. When these conditions prevail in mining there can be no further economy. Any further reduction in cost must depend upon the natural advantages, and not upon labor or capital. We can perfect the engine and economize in steam, but we cannot alter the laws of combustion. We might as well undertake to utilize every heat unit of coal in a locomotive fire-box, under forced combustion, as to harmonize all the evils of human nature.

The economies of coal mining cover such a vast field that it is impossible to enter into details within a limited space; but the entire structure is based upon the capacity of labor measured in tons. Labor can better afford to work six days in the week at $1.01 than half-time at $2 per day, and capital cannot keep labor idle without decreasing the earnings of both. Overcapitalization is one of the greatest obstacles against which the miner must contend at present. A railway costing $25,000,000 and capitalized at $50,000,000 must double its burden on the mine, and affect the cost of coal in the market precisely as if labor demanded double wages. In many cases, if not the rule, the capital represented by our transportation lines is more than double the actual cost or real value, and this evil must be remedied before the most economical results can be obtained. In some cases coal is being hauled long distances at, or below, actual cost, but in such instances the locals, or rates on supplies, must be abnormally high. The mine, therefore, must bear, directly or indirectly, the same burden. It is as

essential to economize in capital as in labor, and an overburden in either must lead to failure in close competition. There seems to be no remedy, however, for over-capitalization except by foreclosure, which is employed only as a last resort when earnings have been forced to zero. Our capacity to produce being more than double the consumption the time has arrived when all must lay idle one-half the time, or one-half must lay idle all the time. In other words, only the fittest can survive, and these must necessarily be found among such as possess the greatest natural advantages, coupled with the most intelligent management.

The practical operations of a coal mine, like those of the railways of the country, have been thoroughly systematized, and the different items of cost tabulated in the simplest forms. The following is a good form of daily report which is compiled from the pay rolls and other sources. The last column "cost per ton," represents the total, apart from fixed charges, and shows any variation and the cause at a glance. The items are, of course, made to conform to each individual mine and conditions.

_____COAL COMPANY,_____189____

DAILY REPORT OF MINE COST.

No.	Name.	Cost Per Day Each.	Total Cost Per Day.	Date.	No. Tons Coal Run	Total Cost.	Cost Per Ton.	Remarks.
.....	Mules.....	.....	.....	1	.....	.....	.....	.....
.....	Drivers.....	.....	.....	2	.....	.....	.....	.....
.....	Locomotives.....	.....	.....	3	.....	.....	.....	.....
.....	Foremen.....	.....	.....	4	.....	.....	.....	.....
.....	Trackmen.....	.....	.....	5	.....	.....	.....	.....
.....	Timbermen.....	.....	.....	6	.....	.....	.....	.....
.....	Laborers.....	.....	.....	7	.....	.....	.....	.....
.....	Furnacemen.....	.....	.....	8	.....	.....	.....	.....
.....	Trappers.....	.....	.....	9	.....	.....	.....	.....
.....	Smithshop.....	.....	.....	10	.....	.....	.....	.....
.....	Overhaulers.....	.....	.....	11	.....	.....	.....	.....
.....	Oilers.....	.....	.....	12	.....	.....	.....	.....
.....	Knuckelmen.....	.....	.....	13	.....	.....	.....	.....
.....	Incline repairs.....	.....	.....	14	.....	.....	.....	.....
.....	Weighmasters.....	.....	.....	15	.....	.....	.....	.....
.....	Tipplemen.....	.....	.....	16	.....	.....	.....	.....
.....	Loaders.....	.....	.....	17	.....	.....	.....	.....
.....	Pumpmen.....	.....	.....	18	.....	.....	.....	.....
.....	Machinist.....	.....	.....	19	.....	.....	.....	.....
.....	.....	.....	.....	20	.....	.....	.....	.....
.....	.....	.....	.....	21	.....	.....	.....	.....
.....	.....	.....	.....	22	.....	.....	.....	.....
.....	.....	.....	.....	23	.....	.....	.....	.....
.....	Yardage.....	.....	.....	24	.....	.....	.....	.....
.....	Oil and waste.....	.....	.....	25	.....	.....	.....	.....
.....	Bank rails.....	.....	.....	26	.....	.....	.....	.....
.....	Lumber.....	.....	.....	27	.....	.....	.....	.....
.....	Nails and spikes...	.....	.....	28	.....	.....	.....	.....
.....	Coal used.....	.....	.....	29	.....	.....	.....	.....
.....	Miscellaneous.....	.....	.....	30	.....	.....	.....	.....
.....	.....	.....	.....	31	.....	.....	.....	.....
	Monthly total.....	.....	.....	.....	.....	.....	.....	.....

Coal mined.....Tons.....Pounds.

A comprehensive mine pay roll is one of the most important auxiliaries, and where a company store is conducted, and especially where negro labor is employed, it is necessary that such a roll should show the daily balance at a glance. Such a roll is that which we publish. It shows the debits and credits in parallel columns. Each day's coal is entered in pounds, tons or bushels, as the case may be, in the unit column, and the debits are entered on same line in red ink, within the lines marked "$" and "c." At the end of the month, or week, a

miner may have other credits than coal, such as "yardage," which is a fixed allowance for narrow work, "day's labor," or other extra compensation in addition to his tonnage. His "store account" is generally recorded by some system of orders which are charged on the roll under the date they are issued and the total carried forward under the heading in "debits." When a miner draws all of his supplies and support from a company store, and has steady employment, about 50% of his total "credits" is about the average of his "store account" and other debits. The rents vary from $3 to $6 per month on houses containing three and four rooms. As a rule each miner carries his daily supply of "fuel" home in a sack when he quits the mine, in which event, in some cases, no charge is

MINING PAY ROLL FOR THE MONTH OF _____ 189__

_____ COAL COMPANY.

Name of Employé.	Occupation.	No.		No. of Pounds of Coal Per Diem. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total Lbs.
Jno. Smith	Miner..	33	Dr. $ c.		3.50	2.00		1.00							Cash 5.00								Cash 5.00										35.00
			Cr.	26,500	19,350	30,450		21,200																									448,000
.....	.....		Dr. $ c.																														
			Cr.																														

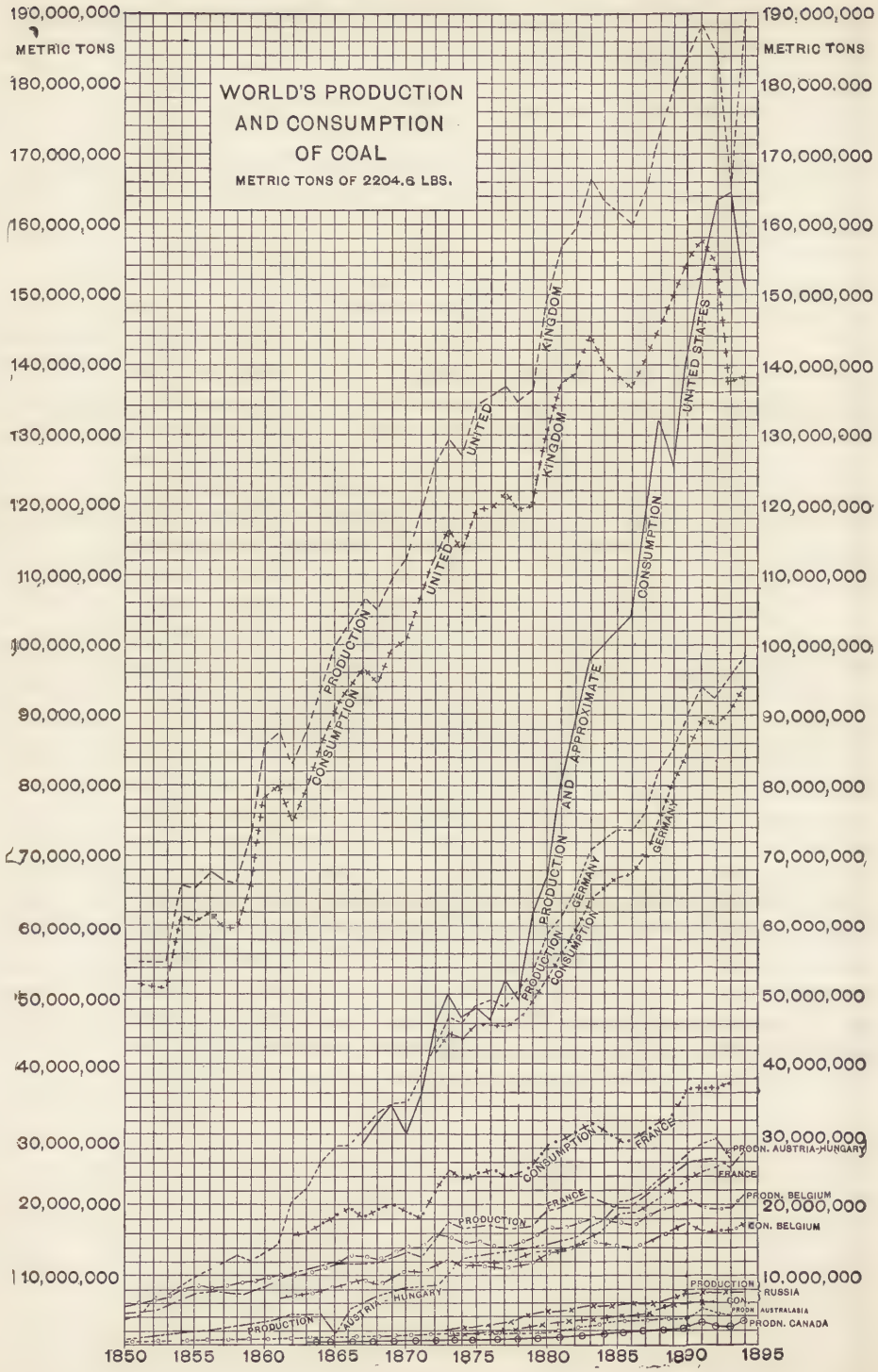
CREDITS.										DEBITS.								
			Yardage.			Days' Labor.												
2240 Lbs. Tons Total.	Price Paid Per Ton.	Total Am't Due for Coal.	No.	Price Per Yard.	Total Am't.	No. Days.	Rate Per Day.	Total Am't.	Total Credits.	Store Acc't	Rent.	Fuel.	Smithing.	Doctor.	Cash Adv.	Total Debits.	Bal. Due.	No.
200	$0.20	$40.00	10	$1.00	$10.00	4	$1.50	$6.00	$56.00	$25.00	$3.00	$1.00	$1.00	$0.50	$10.00	$40.50	$15.50	33
.....	.....	.....	..	.....	.....	..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..
.....	.....	.....	..	.....	.....	..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..
.....	.....	.....	..	.....	.....	..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..
.....	.....	.....	..	.....	.....	..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..

made. In many cases, however, a fixed charge per month is made for such coal, whether it is carried by the miner in a sack, or hauled by the company. "Smithing" is a fixed charge for sharpening tools, based either upon the tonnage, per cent. of earnings, or the month. This charge varies from 50c. to $1 per month. The "doctor" receives from each single miner and laborer 50c. and from each married man $1 per month, for which he furnishes both medicine and attendance, with no extra charge except in cases of labor and venereal diseases, in which $5 extra is customary. In some instances the company employs the doctor at a stated salary and makes a profit out of this column, but as a rule the

collections are made for the sole benefit of the physician, with or without a commission. This charge is often compulsory, even where the company retains no part of the proceeds, and as a rule the miners prefer that it should be so.

In exceptional cases "cash is advanced" at any time during the month and simply deducted from the "credits," but in a great number of cases this column might be omitted from the roll. The "total debits" deducted from the "total credits" leave the "balance due," which is presumably paid in cash, weekly, semi-monthly or monthly.

While there is a vast difference in prices paid for digging in different coals and districts, there is not so much variation in the miner's earnings and daily wages as might be presumed at first sight. In soft coals the miner receives from 20c. to 50c. per ton for digging and loading "run of mine" coal, but owing to natural conditions and individualities of the different coal measures, previously referred to, he may frequently earn more at 20c. in one mine than he would at 50c. in another. Considering his earnings, or "credits," a good miner can load from 4 to 10 tons of coal daily, within eight hours' time; in favorable workings he can do more, but where this output can not be maintained with a fair expenditure of labor, because of such difficulties as are not general, such as water, narrow work, slate partings in the coal bed, bad roof, etc., an extra compensation in the shape of "yardage" or "day's labor" sufficient to equalize the conditions is necessary in order to prosecute the workings uniformly. Upon the prices named, the "total credits" of a miner, with steady work, will run from $40 to $60 per month, out of which he has to pay for his powder and oil, the former varying in proportion to his price per ton, the latter being about 5c. per day. A fair monthly average for both would be $5. An average miner can, and does in the great majority of mines, earn about $50 per month, provided he has steady employment, or "a full run" as he calls it; but he rarely gets the cash value of his earnings. The commissaries furnished him, upon which there are profits of from 50% to 100%, absorb a part, and reduce his earnings from 25% to 50% when he passes it all through the store; but the most unsatisfactory deductions with which he has to deal are the screen and payment by the car, or measure, instead of by actual weights. In both he is often swindled and knows it; but submits to the indirect tax rather than admit the facts and meet the necessity squarely. In addition to the digging price the dead work, such as is detailed in the daily report blank, will aggregate from 20c. to 30c. per ton, depending largely upon the output and other conditions, and to this again must be added royalty (or its equivalent), depreciation, and office expenses.


WORLD'S PRODUCTION AND CONSUMPTION OF COAL
METRIC TONS OF 2204.6 LBS.
METRIC TONS
190,000,000
180,000,000
170,000,000
160,000,000
150,000,000
140,000,000
130,000,000
120,000,000
110,000,000
100,000,000
90,000,000
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
1850
1855
1860
1865
1870
1875
1880
1885
1890
1895
UNITED KINGDOM PRODUCTION
UNITED KINGDOM CONSUMPTION
UNITED KINGDOM APPROXIMATE PRODUCTION AND CONSUMPTION
UNITED STATES CONSUMPTION
GERMANY PRODUCTION
GERMANY CONSUMPTION
FRANCE PRODUCTION
FRANCE CONSUMPTION
AUSTRIA-HUNGARY PRODUCTION
PRODN. AUSTRIA-HUNGARY
PRODN. BELGIUM
CON. BELGIUM
PRODUCTION RUSSIA
CON.
PRODN. AUSTRALASIA
PRODN. CANADA

COPPER.

THE copper industry has made immense progress in the United States within a few years, and though in both Volumes I. and II. of THE MINERAL INDUSTRY large space was devoted to accounts of that progress, yet the advance recorded in the present volume must be considered little short of marvelous.

The admirable monograph on "Improvements in Copper Smelting," by Dr. Peters, the first living authority on the subject, tells in that most practical form—working drawings and actual costs of operation—the story of wonderful progress in every department of the work. The improvements in roasting furnaces are startling, and are known to but few metallurgists even in this country. The pyritic smelting and bessemerizing of copper as now carried out in the most modern plants have effected great reductions in costs and are very notable advances in metallurgical practice. The electrolytic refining of copper has attained a degree of perfection not dreamed of a few years ago, and probably not attained elsewhere in the world, and its cost, at well-planned works, is now below half a cent a pound. No less than 150,000,000 lbs. were refined electrolytically in 1894. The effect of these great improvements is apparent in the increasing production of copper in the United States even in 1894, when the price of the metal reached the lowest point ever recorded.

Copper was the only one of the important metals of which the production in this country steadily increased through the lowering prices of the panic years and the depression in trade. Consumption in 1894 amounted to 176,259,646 lbs., which, though less than in 1891 and 1892, was considerably greater than in 1893. The amount consumed was a little greater than that exported.

The total production from domestic ores in 1894 was 353,504,314 lbs., or 8% greater than in 1893. The amount smelted in the United States from imported, mostly Canadian, ores was 8,279,761 lbs., which was a little more than in 1893, though less than in 1891 and 1892. The imports of ores for smelting here should hereafter increase, for the cost of smelting and refining is lower in this than in any other country.

The imports of copper in bars, ingots and old metal amounted to only 3,446,724 lbs., and this, added to the total amount smelted and to the stock on hand at the beginning of the year, gave us a gross supply of 423,470,799 lbs., or 189,049 long tons. The exports, though a little less than in 1893, still

amounted to 169,651,153 lbs., or 75,737 gross tons, and only 6,107,984 lbs. of this was exported in ore, regulus or matte.*

The stock of copper on hand at the end of 1894, including that held in matte or other marketable form and in process of refining, was larger than at the close of the preceding year, as was to be expected because of the enormous increase of capacity of our electrolytic works, and yet it was only about 20% of our production. As a rule producers have not large stocks; they have generally sold as fast as the copper was ready. Deducting the exports and stocks from the total supply we get the consumption, which amounted to 176,259,646 lbs., or 78,687 long tons. The quantity of copper refined electrolytically in this country in 1894 attained 150,000,000 lbs.

The outlook for the copper industry is excellent. Consumption, especially in electric work, is growing at a rapid rate, and with the revival of business it is probable that the home demand will absorb nearly our whole production, and that prices will advance somewhat, though those of some years ago will probably never be seen again. Even the very low price of 1894 was not without a fair profit to the majority of our producers.

COPPER PRODUCTION IN THE UNITED STATES.

(Pounds of fine copper.)

States.	1891.		1892.		1893.		1894.	
	Pounds.	Long Tons.	Pounds.	Long Tons.	Pounds.	Long Tons.	Pounds.	Long Tons.
Arizona	41,894,699	18,703	38,383,116	17,135	43,773,675	19,542	44,531,108	19,880
California	3,750,000	1,673	3,200,000	1,430	2,825,773	1,261	120,156	54
Colorado	7,000,000	3,125	7,250,000	3,236	7,121,257	3,179	6,528,214	2,914
Michigan	114,107,424	50,940	108,179,576	48,294	113,537,793	50,686	114,526,555	51,128
Montana	112,359,839	50,161	161,051,477	71,898	154,300,100	69,330	183,094,755	81,739
New Mexico	1,600,000	714	500,000	223	273,515	123	154,730	69
Utah	1,700,000	759	2,000,000	893	1,312,171	585	1,183,098	528
Eastern and Southern States	1,300,000	580	1,300,000	580	415,025	185	2,437,986	1,088
All others	3,157,424	1,409	1,211,416	540	3,441,168	1,535	927,712	414
Total domestic production	286,869,386	128,064	323,075,585	144,229	327,000,477	146,426	353,504,314	157,814
From foreign ores	11,500,000	5,185	10,200,000	4,553	7,723,387	3,448	8,279,761	3,696
Total smelted	298,369,386	133,249	333,275,585	148,782	334,723,864	149,874	361,784,075	161,510
Stock, January 1	101,000,000	45,089	75,414,848	33,667	55,434,300	24,743	57,418,689	26,073
Imports of bars, ingots and old	4,174,057	1,408	1,552,515	693	5,536,690	2,472	3,446,724	1,539
Total supply	403,543,443	179,746	410,242,948	183,142	395,694,554	177,089	422,649,488	189,122
Deduct exports	115,122,067	51,394	190,036,800	40,198	180,066,880	80,387	167,651,153	75,737
Deduct consumption	213,006,528	94,685	264,772,148	118,201	158,208,985	70,629	176,259,646	78,687
Stock, December 31	75,414,848	33,667	55,434,000	24,743	57,418,689	26,073	78,738,689	34,698

Arizona.—The production of copper in Arizona increased slightly in 1894, the increase coming from the United Verde, Detroit, and Arizona Copper Company's mines, the Old Dominion having fallen off heavily and the Queen to a less amount. The United Verde has developed a very fine property and is said to promise a large output. Arizona possesses many promising copper properties, and though the rich oxidized ores give place to the lower grade sulphides as depth is attained, the costs of treatment decline even more rapidly than the grade, and in other States the profits may even increase while the ore deteriorates.

*All import and export figures are from the reports of the United States Bureau of Statistics. The Bureau reports exports of "ore" and "regulus," in long tons, which means for the most part matte and black copper, but does not state their contents in fine copper. From careful inquiry we have counted the ore and matte as averaging 55% and regulus 90% copper.

At the mines of the Arizona Copper Company work has proceeded quietly and in the usual way. The leaching plant established by the company has been, it is understood, working in a very satisfactory way. The company makes sulphuric acid from its roasting furnaces, using it in the process.

The Copper Queen Consolidated Company has maintained its production at the same rate as for several years past, but at its mines has reduced development work as much as possible. This company has, however, made arrangements to treat the large bodies of sulphide ores which have remained exposed but not utilized for some time past. A Bessemer plant has been erected in which Douglas' trough converters are used, the intention being to mix oxidized and unoxidized ores in such proportion as will make a matte of suitable richness. The results have been very satisfactory. In this way the cost of a calcination plant and of calcination will be saved. At Globe the company has done nothing, not even exploration work, and the same thing can be said of the mines at Copper Basin.

The Old Dominion Company at Globe produced no copper, but has a force at work sinking the mine shaft to a depth of 500 ft. from the surface and also drifting from the eighth level. It is expected that this company will soon begin producing ore again. Several small copper enterprises have been projected and one or two started, but so far without success. It seems probable that as long as the present conditions continue no addition will be made to the old list of producers, other than the Clark property. On this property, at Jerome, it is understood that work is in progress, but the details are kept secret as far as possible. A narrow-gauge road is under construction to the mines, and a Bessemer plant is in course of erection.

COPPER PRODUCTION IN ARIZONA.

(Pounds of fine copper.)

Mine.	1890.	1891.	1892.	1893.	1894.
Arizona	5,164,906	5,673,611	5,893,533	7,871,819	9,935,812
Copper Queen	13,120,934	13,022,957	12,916,416	13,795,618	12,968,372
Commercial	.....	.....	282,451	273,330	90,805
Detroit	4,906,704	4,194,672	1,918,594	4,942,728	5,577,744
Old Dominion	7,411,214	6,982,101	7,698,297	7,665,293	4,839,386
United Verde	5,475,573	7,350,087	9,524,492	9,121,146	10,904,453
United Globe	398,849	2,302,765	.....	.....	.....
Other mines	499,012	2,368,506	149,333	103,741	214,536
Total	36,977,192	41,894,699	38,383,116	43,773,675	44,531,108

California.—The one important copper mine in California was not worked during the year and consequently the output of the State makes a very poor showing.

Colorado.—The output of the several districts which produce ores containing more or less copper was well maintained during 1894; in fact, the output of the State in lead, silver, and gold, as well as copper, was greater than expected. In copper there was a slight decline as compared with the output for a number of years past, but it is expected that in the present year the lost ground will be recovered. The production of the State is made up altogether from ores mined for other metals than copper.

Michigan.—The production of Michigan increased 1,000,000 lbs. and for several years has varied but little. Our statistics of its production for the years 1891, 1892, and 1893 have been slightly changed, the Calumet & Hecla having abandoned, to this extent, its former policy of secrecy, and having courteously furnished us with official returns for these several years as well as for 1894. The close approximation to these figures, which we had arrived at independently and in the face of erroneous official figures furnished by the State of Michigan, shows with what care and accuracy the statistics of THE MINERAL INDUSTRY are compiled.

If the Calumet & Hecla will now advance a step further and publish, for the benefit of its stockholders and the credit of the mining industry, full information as to its cost of mining and treatment of ores, it will receive the gratitude of all who desire to see mining rendered an honest and honorable industry. The policy of secrecy followed by a company which has always enjoyed the reputation of being honestly, albeit extravagantly, managed is cited as a justification of the same policy when used to cover facts perhaps less creditable than extravagance.

The great event of the year in the Michigan mines has been the completion of the two deep Tamarack shafts, the deepest in the world, No. 3 being 4218 ft. deep and No. 4 shaft 4143 ft. and the sinking of the Calumet & Hecla deep vertical shafts, which at the close of the year were about 3900 ft. deep and will ultimately attain the immense depth of 5000 ft. The ore in these deep mines has, apparently, lost little in its richness, but it is now generally recognized that the copper from them has lost something in its purity, as is shown in its loss of electrical conductivity—the most delicate test we have of purity. This deterioration is generally attributed to the closer concentration, which furnishes a less pure "mineral" for smelting, and, possibly, to the presence of minute quantities of iron in the copper.

COPPER PRODUCTION IN MICHIGAN.
(Pounds of fine copper.)

Mine.	1890.	1891.	1892.	1893.	1894.
Allouez	1,407,828	1,241,423	546,530	.....	.....
Atlantic	3,619,972	3,653,671	3,703,875	4,221,933	4,437,609
Calumet & Hecla	58,836,904	63,294,634	58,292,576	62,825,674	61,842,722
Centennial	.....	435,784	.....	.....	.....
Central	1,413,391	1,321,417	1,625,982	1,177,500	584,950
Copper Falls	650,000	1,440,000	1,400,000	1,000,000	.....
Franklin	5,638,112	4,319,840	3,767,000	3,504,244	3,602,608
Huron	1,736,777	1,215,734	461,499	562,776	.....
Kearsarge	1,598,525	1,727,390	1,580,192	1,546,318	1,998,710
Mass	60,000	30,114	17,450	22,737	41,805
National	123,897	103,888	36,385	63,433	36,390
Osceola	5,294,792	6,543,358	6,894,256	6,216,975	6,879,000
Peninsular	1,108,660	1,599,670	973,217	.....	.....
Quincy	8,064,253	10,542,519	11,015,686	14,398,477	15,484,014
Ridge	17,645	43,049	41,462	25,988	52,481
Tamarack	10,106,741	16,161,312	16,426,633	15,085,113	15,375,000
Tamarack Junior	.....	.....	796,769	1,610,259	2,350,000
Wolverine	.....	312,112	500,074	1,025,062	1,665,255
All other mines	1,017,503	121,509	11,750	251,304	176,011
Total pounds	100,695,000	114,107,424	108,179,576	113,537,793	114,526,555

The Atlantic mine ore has been richer than for some years past. The fact that an ore yielding only 0.7% of copper, or 14 lbs. to the ton of ore treated, has

made a profit, is an eloquent testimony to the skill and economy of the management of Mr. F. McM. Stanton. The Atlantic Company, having reached the limit of dumping ground in Portage Lake at its old mill, was obliged to build a new mill near Lake Superior on the Salmon Trout River, and has built a railroad to connect this with the mine. The improvements adopted will doubtless still further lower its marvelously small costs, which in 1894 were as follows, per ton of rock treated: Mining, selecting and breaking, all surface expenses, including taxes, $0.7518; transportation to mill (3 miles), $0.0303; stamping and separating, $0.2330; total working expenses at mine, $1.0151; add freight, smelting and marketing product, including New York office expenses, $0.1771; this makes running expenses $1.1922. The total expenditure per ton of rock treated, including construction of new mill, was $1.6507.

The Tamarack, Tamarack Junior, Kearsarge and other companies under the same financial administration have ceased to make such public statement as would permit of an analysis of costs. It is evident, however, that costs are increasing somewhat and that the selling price of the copper as compared with that of other Lake mines is declining, but it is not certain that this latter is due to a deterioration in the quality of the copper as the mines become deeper.

Montana.—This State has for several years past stood far in the lead as a copper producer; its output in 1894 amounted to no less than 183,094,755 lbs. and was far greater than ever before in its history. This increase came chiefly from what are called "the small mines." All the old mines were worked to full capacity. The Anaconda produced over 20,000,000 lbs. more than in 1893, but not as much as in 1892.

The production of the Boston & Montana and the Butte & Boston has been given together because little reliance is placed upon the several differing official reports we have received. It is greatly to be regretted that full information concerning these properties is not given by the companies. The Montana Ore Purchasing Company has become a large producer from ores purchased from a number of mines. In our table its output has been grouped with all the unenumerated producers.

The article on the mining and surface plants at Butte gives full information concerning the mines of the district and renders it unnecessary to add to these notes. The article on "Improved Methods of Copper Smelting," by Dr. E. D. Peters, gives the latest information on some of the plants in use.

The copper works at Great Falls, Mont., are doing excellent work with good plant, as described also by Dr. Peters, in his monograph just referred to.

COPPER PRODUCTION IN MONTANA.
(Pounds of fine copper.)

Mine.	1890.	1891.	1892.	1893.	1894.
Anaconda	64,046,812	46,500,000	100,000,000	75,256,657	95,578,000
Boston & Montana	26,942,298	26,507,929	30,386,595	31,800,000	
Butte & Boston	5,485,434	18,392,054	10,641,269	20,457,928	57,937,633
Butte Reduction Works	3,001,209	2,915,000	2,864,000	2,985,485	2,282,000
Colorado S. & M. Co	2,320,000	3,641,384	4,560,972	6,703,488	5,158,730
Hecla Con. M. Co	159,980	91,090	159,859	77,565	362,897
Parrot	9,000,000	14,108,382	12,438,782	7,791,167	7,469,908
Montana Ore Purchasing Co. and others	.....	204,000	.....	9,227,810	14,305,587
Total	110,955,733	112,359,839	161,051,477	154,300,100	183,094,755

The following table shows the total copper production of the United States for 36 years, with the approximate values based upon the selling prices of lake copper in New York, which is taken as the standard, a table of which is given elsewhere in this article.

COPPER PRODUCTION IN THE UNITED STATES, 1859–1894. (a)

(In tons of 2240 lbs.)

Year.	Tons.	Value.	Year.	Tons.	Value.	Year.	Tons.	Value.
1859	6,300	$2,963,520	1871	13,000	$6,258,980	1883	52,101	$17,995,000
1860	7,200	3,409,056	1872	12,500	8,778,000	1884	66,138	18,148,250
1861	7,500	3,052,350	1873	15,500	9,565,360	1885	75,934	18,292,999
1862	9,000	4,931,640	1874	17,500	8,658,300	1886	72,428	16,630,660
1863	8,500	5,946,430	1875	18,000	8,618,400	1887	82,700	21,115,916
1864	8,000	7,873,600	1876	19,000	8,490,720	1888	104,338	34,194,179
1865	8,500	6,556,900	1877	21,000	8,323,120	1889	109,253	28,646,300
1866	8,900	6,013,196	1878	21,500	7,549,080	1890	119,609	30,930,800
1867	10,000	5,346,600	1879	23,000	8,381,660	1891	133,249	38,447,665
1868	11,600	5,831,784	1880	27,000	11,491,200	1892	148,782	36,719,400
1869	12,500	6,217,750	1881	32,000	12,175,600	1893	149,874	35,257,860
1870	12,600	5,529,950	1882	41,191	16,143,500	1894	161,510	33,614,915

(a) Includes copper smelted from foreign ores.

It will be interesting to follow this table of the course of production and prices, and to note the enormous increase from 6300 tons in 1859 to 157,814 tons in 1894, the output last year having been over 25 times as great as it was 26 years ago. From 1859 to 1870 the increase was gradual, but steadily increased with the exception of some fluctuations during the years of the war period. In 1870 it was twice as great as in 1859. From 1871 to 1883 the increase was continuous and more rapid, and in the last-named year the total was a little more than four times that of 1871. With the opening of the Montana mines the tonnage gained rapidly; the only year which did not show a large increase was the exceptional one of 1886, and last year the total reached an amount three times as great as that of 1883. Such a growth in a mining industry like that of copper is phenomenal and no parallel for it can be found anywhere in the history of the mineral industry.

It was not to be expected that with such an enormous increase in production, accompanied as it has been by a decrease in cost of mining and working the ores, and also by a general fall in prices of the materials of construction of all kinds, that copper should maintain its former value. Accordingly we find, taking the two extreme years given in the table, that while the production in 1894 was over 25 times as great as that of 1859, the value or selling price in the latter year was only about 11 times that at the earlier date; the averages of the two years were respectively 21c. and 9c. per lb., showing a decrease of 63% in price.

The World's Copper Production.

The following table shows the production of copper in the different countries of the world for the three years 1892, 1893 and 1894, and for convenience of reference we have given the quantities both in long tons (2240 lbs.) and in metric tons. From nearly all the countries given we have been able, through the courtesy of the producers, to give exact figures, and in the few cases where these were not obtainable they have been supplemented by the estimates of Messrs. Henry R. Merton & Co., who are recognized authorities in the trade.

THE WORLD'S COPPER PRODUCTION, 1892–1894.

Countries.	1892.		1893.		1894.	
	Tons of 2240 lbs.	Metric Tons.	Tons of 2240 lbs.	Metric Tons.	Tons of 2240 lbs.	Metric Tons.
Australasia	6,092	6,191	7,500	7,621	9,000	9,144
Austria-Hungary	1,385	1,407	1,400	1,423	2,120	2,154
Bolivia	2,860	2,906	2,500	2,540	2,300	2,337
Canada	4,130	4,197	3,630	3,679	3,786	3,847
Cape of Good Hope—						
Cape Company	5,350	5,437	5,225	5,309	5,150	5,233
Namaqua	1,378	1,405	890	904	1,500	1,524
Chile	22,065	22,418	21,350	21,694	21,340	21,681
Germany—						
Mansfeld	14,703	14,937	13,454	13,669	14,963	15,202
Other mines	2,000	2,032	2,951	3,000	2,210	2,260
Italy	2,000	2,032	2,460	2,500	2,500	2,540
Japan	18,000	18,288	18,000	18,288	20,050	20,371
Mexico—						
Boleo	6,313	6,415	7,979	8,107	10,371	10,537
Other mines	1,480	1,500	1,480	1,500	1,400	1,422
Newfoundland	2,400	2,439	2,000	2,032	1,900	1,930
Norway	1,410	1,433	1,740	1,768	1,785	1,813
Russia	5,000	5,080	4,920	5,000	5,000	5,080
Spain and Portugal—						
Rio Tinto	30,200	30,684	31,000	31,499	32,689	33,215
Tharsis	10,800	10,970	11,000	11,177	11,000	11,177
Mason & Barry	4,400	4,470	4,400	4,470	4,200	4,267
Sevilla	1,000	1,016	1,010	1,026	1,170	1,188
Other mines	7,700	7,824	6,500	6,605	4,805	4,882
Sweden	733	745	544	552	500	508
United Kingdom	515	523	420	433	400	406
United States	148,782	151,152	149,874	152,271	161,510	164,194
Venezuela	3,065	3,114	2,861	2,907	2,500	2,540
All other countries	490	498	620	630	670	680
Total	304,251	309,113	306,708	310,704	324,859	330,132

Australasia.—The copper production of the Australasian colonies shows a continuous but not very large increase, although it has attained the respectable figure of 9144 metric tons. A considerable portion of this copper is the product of New South Wales and comes from the silver ores of the Barrier Range. A more marked increase is to be expected when the great copper deposits of Tasmania, the extent of which has been verified as far as possible by preliminary explorations, begin to be worked upon a large scale, as they probably will be within a few years. The copper product of Australasia goes mostly to England.

Austria-Hungary.—About the copper production of the Austrian mines there is little to be said. In 1894 it showed a decided increase over both 1892 and 1893. The output, however, has been subject to similar fluctuations from time to time and apparently no very great increase is to be expected.

Bolivia.—The production of this country showed a slight decrease last year, which is probably chiefly due to the fact that the difficulties of transportation of copper for export have largely prevented the mines of this country from competing with those of other nations at the low prices at present ruling.

Canada.—The production of copper in Canada showed a slight increase in 1894 over that of 1893, but a decrease from 1892. Most of this has been due to the diminution in product of the mines of Quebec. The Sudbury district, where a considerable amount of copper is obtained from the nickel ores of the region, is steadily increasing its production.

Cape of Good Hope.—The principal producer in South Africa is the Cape Copper Company, which has maintained its output with a fair degree of steadi-

ness. This company also controls the production of the Namaqua mines. The copper from the company's properties is principally shipped to England in the form of ore or matte and is converted into metal by the company at the works which it owns near Bristol.

Chile.—The Chilean production shows but little variation and is not larger now than it has been for a number of years. There are several reasons for this state of affairs; most of the Chilean mines have exhausted their richer surface ores and are working the deeper deposits which call for a greater outlay in mining. Chilean copper no longer controls the English market as it did years ago, but has to compete there with the enormous British imports from the United States and other countries. The profits of the industry are much less and there is not the same inducement to continue working. The Chilean copper goes chiefly to Great Britain, and a very large proportion of it is exported in the form of ores and regulus, and is smelted and refined at Swansea and elsewhere.

A change of some importance during the year was the reorganization of the old Panulcillo Company and the transfer of its mines and works to the Central Chile Copper Company, a new organization formed in London where most of the stock was owned.

Germany.—In this country the Mansfeld Company continues to be the great producer. Its mines furnish about 90% of all the copper reported for the country. Like all the other producers, the Mansfeld has felt the effect of increased production and lower prices, but has met this movement to a considerable extent by improvements and reductions in cost at its works. The company has also adopted electrolytic methods of refining, though to a much less extent than some of our own large companies. Of the total production last year 1123 tons were electrolytic copper.

The following very interesting table from the last report of the company shows the course of its working and the average price obtained for its output for a period of 21 years. During that time the amount of copper has increased to about three times that reported in the first year, but the price per ton in 1894 was less than half that obtained in 1874. The table will indicate, moreover, the general course of copper prices in Europe.

PRODUCTION OF THE MANSFELD COPPER MINES, 1874–1894. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Copper.		Silver.		Year.	Copper.		Silver.		Year.	Copper.		Silver.	
	Tons.	Price Per Ton	Kilos.	Price Per Kilo		Tons.	Price Per Ton	Kilos.	Price Per Kilo		Tons.	Price Per Ton	Kilos.	Price Per Kilo
1874..	5,159	$418.52	23,059	$40.94	1881..	10,999	$313.35	59,836	$36.40	1888....	13.759	$347.12	78.696	$30.00
1875..	6,038	428.70	30,057	39.96	1882..	11,691	330.06	62,708	36.34	1889....	15,330	267.39	86,714	29.99
1876..	6,079	394.96	31,088	37.45	1883..	12,836	323.13	68,463	35.50	1890....	16,035	283.53	88,125	33.35
1877..	6.908	362.47	34,960	38.38	1884..	12,774	290.36	74,133	35.53	1891....	15,366	275.13	80,512	30.46
1878..	7,972	334.72	42,685	36.86	1885..	12,365	243.33	75,076	34.05	1892....	14,937	239.12	85,976	27.65
1879..	8,526	292.12	45,258	36.17	1886..	12,787	206.82	75,271	31.83	1893....	13,670	235.67	75,308	24.75
1880..	9,814	334.58	51,586	36.67	1887..	13,224	210.39	75,206	31.23	1894....	16,202	204.28	75,496	20.25

(*a*) From the annual report of the Mansfeldsche Kupferschieferbauenden Gesellschaft for 1894.

The production of the other mines in Germany is not important; they show some fluctuations from year to year, but upon the whole are not gaining in production.

Italy.—The production of Italy continues to have very little change; the chief Italian producer, the Libiola Company, is owned in England, and the metal not consumed at home goes to that country.

Japan.—The production of Japan last year showed a fair increase. It has gained, though not rapidly, since the introduction of modern methods of mining and smelting. The Ashio continues to be the most important mine, although others are being developed and will probably increase their workings hereafter. The Japanese copper is in great part used at home or absorbed by the Chinese and Indian markets, and comparatively little of it makes its appearance in Europe.

Mexico.—The notable event in this country during 1894 was the extraordinary improvement made by the Boleo, which is the chief copper producer of the country. Although the value of the Boleo mines was admitted, the company for a number of years was not fortunate. A radical change in methods and management made some time ago, however, has at last produced its effect and in 1894 the company not only increased its output by about 25% over that of 1893, and 60% over that of 1892, but it was able to pay off an accumulated floating debt of over $500,000, and showed a small credit balance besides. Moreover, many improvements have been made in the mines by the addition of new machinery and the erection of an electric power station from which the working power for the pumps and hoists is transmitted to the different shafts, most of which are located at points where the operation of steam engines would be costly and inconvenient. The Boleo is now in a position to join the list of dividend-paying companies. The product of this mine goes chiefly to France.

A large part of the copper reported for other mines in Mexico is obtained as a by-product from silver ores, some portion of which are obtained at smelting works in this country.

Mexico contains abundant supplies of copper and the workings of different mines will doubtless be undertaken and extended from time to time as the conditions of demand for the metal warrant it. The mines controlled by the Guggenheims at Tapezala, in the State of Aguas Calientes, are being developed to a considerable extent. The production of these mines is to be sent to the United States for treatment in the new copper works at Perth Amboy, N. J.

Newfoundland.—The production of this island does not increase; nearly all of it comes from the Tilt Cove mines which are controlled by the Cape Copper Company, and the ores are sent to England, where they are worked in connection with those from the company's South African deposits.

Norway.—The production of this country, chiefly from the Vigsnaes mines, shows but little change.

Russia.—The copper production of Russia is referred to more particularly in the article about that country elsewhere in this volume. It is believed that there will be a considerable increase in the future, especially from the mines of Eastern Siberia, and development of these has already been begun in one or two instances upon a considerable scale.

Spain and Portugal.—The companies working the great deposits of pyritic ores of the Iberian Peninsula all show a fair increase. The Rio Tinto, the largest and most important company in the world except two or three of our

great American companies, reports an increase of 1190 tons of copper over 1893, which was due partly to an increase in the output of ore and partly to a slight improvement in the percentage of metal. The Rio Tinto Company is continuing its policy of gradually increasing the quantity of ore treated at the mines and diminishing to a corresponding extent that shipped to England, Germany and Belgium as ore or pyrites. The enormous deposits controlled by the Rio Tinto Company show no sign whatever of exhaustion or of diminishing productiveness. The example of the Rio Tinto has been followed by the other Spanish companies with only one or two exceptions. The Tharsis Company increased its output of ore, although a slight decrease in the copper contents prevented the production of metal from showing any material increase. For 1894 the output as estimated was the same as in 1893, but the shipments of ore as pyrites, valued chiefly for their sulphur contents, increased. The Tharsis successfully maintained its English works and is a large manufacturer of sulphuric acid and other products. The Sevilla, which is only a moderate producer, shows a slight increase in output. From the smaller mines in Spain there was generally a decrease in production and their total in 1894 was only about three-fourths as great as in 1893. The Mason & Barry, in Portugal, shows but little change and was able to keep up its production and to find a profit in spite of the low prices in copper.

Sweden.—The copper production of this country varies somewhat, but upon the whole it is not increasing. Its output comes from the Stora Kopparberget, which is not the oldest copper mine in the world but the oldest of which we have any official record. This mine is known to have been working and producing large profits for its owners as early as the year 1228, and in 1650 reached its maximum with an output of 3450 tons. Records of this mine are in existence since 1633, and in Vol. I. of THE MINERAL INDUSTRY a table of its production for 259 years consecutively was given, making one of the most interesting records of mining enterprise in existence. This mine has been worked for nearly 800 years, and is still a steady producer, although the amount now reported is below that obtained in its prime.

United Kingdom.—The copper output of the United Kingdom has never been large, and it is not increasing. The conditions are not favorable to any extension of operations, even were it possible, since imported copper can now be put on the market cheaper than the mines of Cornwall can furnish it.

Venezuela.—The greater part of the copper reported from this country comes from the Quebraba mines. In 1894 there was some decrease shown.

Other Countries.—The output reported for other countries includes that from the Argentine Republic and Peru, with a little obtained from ores worked chiefly for other metals in Algeria, Turkey and Greece. The amount from all these countries is not sufficient to be of importance in the general supply.

As the table shows, about one-half of the copper supply of the world is drawn from the United States, while Spain, the next producer in rank, furnishes one-sixth. Japan and Chili each provide one-sixteenth.

The New York Copper Market in 1894.

While the year 1893 was a great disappointment to all those interested in copper, 1894 was not very much better, and upon carefully reviewing the course of events it will be found that the surprises were perhaps even greater. During the preceding year copper was disturbed by the tremendous financial depression which spread all over the country, and which for a time reduced consumption to quite a nominal figure, almost to nothing. A year ago, however, the outlook was such that it could be fairly anticipated that within a comparatively short time consumption of copper in this country would reassume its normal proportions, *i. e.*, what it was prior to the panic. Unfortunately, this anticipation was not realized, at least not until quite late in the year. Consumption dragged, for manufacturers were poorly supplied with orders, the railroads consumed almost nothing, building operations were greatly restricted, and the year had already somewhat advanced before a larger demand was noticeable for electric purposes, which then practically took the larger part of the copper consumed. Fortunately, the consumption in Europe continued at quite a good rate, and, had not this been the case, nothing would have saved copper from reaching even a lower level than it actually did during the past year. In any case, Europe was not prepared to continue taking such heavy quantities of copper as we have shipped them during the period now under review. Exports during the last six months of 1893 amounted to 57,425 tons of 2240 lbs., against 16,900 tons in the same period of 1892. From Jan. 1 to June 30, 1894, 38,935 tons were shipped, against 19,990 tons during the same months of 1893, while during the period from July 1 to Dec. 31, 1894, the exports were 37,362 tons. This latter was the more disappointing to Europeans, as since the summer there were reports from this side that consumption was on the increase, and that we were approaching the time when the full quantity taken prior to the panic would be consumed here; and this actually proved to be the case for at least two months, say during August and September, but then there was a lull prior to the elections, in consequence of which the market immediately showed signs of weakness, and producers had again to look to export in order to market their produce.

During the year 1893, the lowest price for copper was reached in September, when tremendous sales were made for export at about 9⅛c. to 9¼c. for Lake, but at no time was copper available at such prices here, and the market opened considerably higher in January, when 10¼c. was quoted for Lake and 9½c. to 9⅝c. for electrolytic copper. Very soon, however, with a light demand, values dropped, and in February 9¾c. was reached, at which price the market remained steady until the end of March, when the Calumet & Hecla Company made a large sale, said to be about 5000 tons, at 9½c., and that practically made the market for some time to come. The other Lake companies which had hitherto held for rather high prices were soon compelled to follow suit, and, although the strike on the Great Northern Railroad for some time prevented supplies from being received from the works of the Boston & Montana and the Butte & Boston companies, it did not influence the market to any great extent, and flatness continued to rule. During this time larger or smaller sales of Lake copper were

repeatedly made from first hands, mostly for export, somewhat below the market prices established here ; but at no time did the foreign market take such large lots of Lake copper as were practically necessary to relieve the market here, while the producers and refiners of electrolytic copper showed more readiness to meet the views of foreign buyers, and consequently comparatively larger quantities of this metal were exported. The result of this was that at the beginning of June the Calumet & Hecla Company dropped its price for Lake copper for home consumption to 9c., or the lowest price on record. Consumers bought very freely thereat, and took as much as they could see their way to consuming. In all from 7000 to 8000 tons were taken, and, considering the poor demand for manufactured copper, this was a remarkably large quantity. Very few of the Lake companies could exist at this figure, or pay their shareholders a fair remuneration, and with money as cheap as it was quoted throughout the year, they preferred to take their chances to accepting these prices. Very few sales were therefore made, and Lake copper moved up fully ¼c. after the large Calumet & Hecla sale.

During the summer months the demand again became slacker, and the continued drop in the foreign markets (at one time G. M. B.'s dropped to £37 1½s. and £38, or about the lowest point ever reached) could not but react unfavorably on our market. Prices therefore sagged slowly off, and by the end of August 9c. had again been reached, but only small quantities could be had at that price, as most of the producing Lake companies preferred to abstain from selling.

Then the second surprise of the year was experienced, when at the end of August the Calumet made another sale at 9c., this time of about 10,000 tons, for delivery up to the end of the year, and this left most consumers well filled up. Immediately after this sale was consummated the price of Lake copper advanced to 9¼c. and was held very firmly thereat. Holders of electrolytic copper had also held back with sales, and while at this period during the preceding year the difference between Lake and electrolytic copper was usually ¼c., the large demand which now set in for wire-bars enabled holders to realize full Lake prices; and in some instances even better prices for electrolytic than were obtainable for Lake. The market then continued to be very satisfactory, with such an enormous demand for copper wire-bars that practically the supply was not sufficient. Naturally this influenced prices, which became very firm, and 9¾c. for Lake and 9⅝c. for electrolytic were soon established. Here the market was stimulated by some reports to the effect that the principal producers of copper in the United States were in active negotiations regarding the renewal of an arrangement which existed a couple of years ago to restrict production. Although these negotiations were carried on for some time, an agreement could not be arrived at at the time, principally on account of some factors making demands which the other producers did not feel warranted in granting.

The Anaconda Company, of its own accord, agreed to reduce its monthly output from about 5000 tons of fine copper to about 3000 tons, and the reports given out for the months of November and December have shown that it has lived up to this declaration, although at the time it was received by the trade with great incredulity.

During November the market became dormant. The elections attracted more

attention than did business, but the result did not bring about a change. When the market eased off somewhat, Europe again took larger quantities, especially such lots as were offered at rather below the established market values, which in some instances were quite marked, and very often ¼c. to ⅜c. below European rates. At the beginning of December a large sale was reported from the other side, of about 1000 tons of Lake copper, netting about 9⅜c. f. o. b. New York, when there was a good demand for home trade at 9⅜c. to 9¾c. Meanwhile the demand for wire-bars continued. Electrolytic makers being sold out, and with navigation on the Lakes closed, Lake copper could only be brought down by rail at an extra expense of ½c. per lb.

Considering the low prices ruling for copper, none of the companies showed any readiness to do this, and the Calumet & Hecla Company this time remaining very firm and refusing all bids below 10c., it practically forced all buyers to come to this figure, and during the last fortnight in December this price was paid for about 1500 to 2000 tons. So far as can be judged now, there is little likelihood that cheaper prices will be accepted for some time to come.

The market for casting copper followed closely that of Lake copper with small fluctuations, the difference being from ¼c. to ⅜c. and the closing prices for casting copper are 9⅜c. to 9½c., but it appears that the consumptive demand for this grade of copper has materially fallen off.

The following table shows the variation in prices in New York for five years past, the averages for each month of the year being given:

AVERAGE PRICE PER POUND OF LAKE COPPER AT NEW YORK.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1890	14.800	14.333	14.500	14.400	15.125	16.000	16.800	15.400	17.000	16.900	16.800	15.900	15.750
1891	14.750	14.500	14.000	13.750	13.200	13.000	13.000	12.200	12.500	12.250	11.000	10.625	12.625
1892	11.000	10.625	10.375	11.500	11.625	11.875	11.500	11.500	11.125	11.500	11.875	12.375	11.500
1893	12.125	12.000	11.875	11.375	11.000	11.000	10.875	10.000	9.875	9.750	10.000	10.250	10.750
1894	10.125	9.625	9.813	9.500	9.800	8.938	9.000	9.125	9.400	9.875	9.600	9.800	9.550

In addition to this table it may be of interest to give the yearly average of prices on the New York market for 35 years past. The monthly averages for this period will be found in THE MINERAL INDUSTRY, Vol. II.

	Cts.		Cts.		Cts.		Cts.		Cts.		Cts.		Cts.
1860	22.250	1865	36.250	1870	20.625	1875	22.500	1880	20.125	1885	11.125	1890	15.750
1861	19.125	1866	31.750	1871	22.625	1876	21.000	1881	18.125	1886	11.000	1891	12.625
1862	25.250	1867	25.125	1872	33.000	1877	18.625	1882	18.500	1887	11.250	1892	11.500
1863	32.875	1868	23.625	1873	29.000	1878	16.500	1883	15.875	1888	16.667	1893	10.750
1864	46.250	1869	23.375	1874	23.250	1879	17.125	1884	13.875	1889	13.750	1894	9.550

In the main, production of copper has again been very large. Montana remains in the lead, with Michigan a good second, while Arizona has kept up fairly well, and the smaller producing States, such as Colorado, California and Utah, have mostly increased somewhat. The details of the production will be found in the accompanying tables.

One of the main features during the year was the falling off in exports of copper in form of furnace material, and nearly everything that has been exported

was in the form of refined copper. This has caused foreigners to bid higher prices for raw material, and also to finally submit to the terms of the sellers and to buy on American weights and assays. An incident of some interest in the New York market was the sale in November of about 6000 tons of Boston & Montana matte containing very little silver, which material was put in store during the year 1888 for account of the French syndicate; it is understood that there was some litigation about this lot. The selling price was 8s. 3d., c. i. f. Liverpool, and considering that the cost price was at least 15s., and that there was about six years' interest, rent, insurance, etc., to be added, the loss on the transaction is apparent. The exports of matte from New York during the closing weeks of the year were from this lot.

Production of electrolytic copper in this country has again largely increased; not alone have some of the old established refiners, such as the Balbach Smelting and Refining Company, the Baltimore Electrolytic Company, and the Bridgeport Copper Company, increased their output, but new works have been started or enlarged. Among the latter we have to mention the works of the Nichols Chemical Company, at New York; the Boston & Montana Company, at Great Falls, and the electrolytic works of the Anaconda Company, at Anaconda, and thus one of the main desires of the American producers—to bring their copper products on the market as refined metal—has at last been realized. Although values show a decided advance since the low prices touched during the summer, prices for copper in general may still be considered very low, and the future appears to be brighter than the past has been. The large consumption of the metal which continues cannot but influence its value, the more so that no new deposits of copper have been developed.

The London Copper Market in 1894.

The new year opened with G. M. B. copper at £43, and the price underwent, in the course of January, a steady decline, amounting in all to about 35s. per ton. By way of comparison we may also note that the first month of 1893 witnessed a fall of from £47 to £45. This time, as last, the main factor in the depression was of a statistical nature, the American shipments to Europe in December, 1893, having amounted to over 8000 tons, or more than double the monthly quota permitted under the old agreement. Throughout the greater part of the year under review, the extent of American exports continued to largely dominate the course of our market, deterring active speculation, and also depressing, by the abundance and cheapness of American copper, the values of English refined sorts, the margin of which, as compared with G. M. B.'s, had already undergone a notable shrinkage. By far the greater part of these American shipments now consists of bars and refined copper (chiefly electrolytic), America herself consuming nearly the whole of the furnace material which she formerly sent to Europe; indeed, America has now become herself an occasional buyer of such material, especially argentiferous, which is in great request for the electrolytic production of copper. The result is the abundance and keen competition of American refined copper in Europe referred to above, and a great scarcity of raw material.

Consumption in England was fairly good during January, some big orders for ships having been given out, while India, during the first fortnight especially, took fair quantities both of ingot and of manufactured copper. In the second fortnight, the demand was checked by the perturbed state of Eastern exchange and the drop in silver. When the month closed the following were the values of the leading descriptions: G. M. B.'s cash, £41 5s.; 3 months, £41 15s.; tough qualities, £43 10s.@£44; best selected qualities, £44 10s.@£45; "strong" sheets, £53; India sheets, £50, and yellow metal squares, 4½d. The visible supply of copper is now 47,152 tons.

In February the leading feature was the continued and heavy fall in silver, from 30½d. to 27¼d., whereby trade was greatly disorganized and the values of G. M. B. copper depressed still further, the drop for the month being 12s. 6d. per ton. The American shipments were 2000 tons less than for January, but the competition among American producers still resulted in excessive production and constituted a standing menace to the market. The offers of American copper were, however, in most cases too high for European buyers, while English smelters showed themselves more ready to meet the market and take advantage of the situation. At the end of the month an order was given out by the British Admiralty for 1000 tons of "best selected" copper, and this description of copper was thus rendered temporarily scarce and dear.

Throughout March the speculative market was dull and its monotony was unbroken by any new phase or salient circumstance. The G. M. B. value continued to decline until £40 had been reached—the lowest price touched since the break-up of the French syndicate. The market then steadied itself, assisted by the improvement of 1200 tons in the statistics for the first fortnight, and a reaction took the value up to £41 7s. 6d., from which it again relapsed to £40 16s. 3d., the closing value. In America consumption showed some signs of revival and producers there were still holding for prices above the European parity, so that further sales for export were not practicable, but there was still a good deal of American and other copper (in second hands) available, while consumers in Europe were already well stocked by their earlier purchases.

Messrs. Henry R. Merton & Co.'s "Production Statistics for 1893," published this month, showed a total reduction of about 7000 tons in the world's output, this reduction being chiefly due to the operation of the Producers' combination during the first half of that year, after which it ceased to exist.

April was a month of lower values all round, both in the speculative market and for refined sorts. In the latter kind English makers were still able to undersell American copper, the production of which was also, to a certain extent, hampered by railroad strikes and other labor disturbances. Nevertheless, America was able to offer rough copper, though at slightly over G. M. B. values, but the glutted state of our market rendered business at good prices practically impossible. The range of G. M. B. prices during this month was from £41 2s. 6d. to £39 17s. 6d., the close being as the worst.

In May, despite improving statistics, we had a still further declining market. This anomalous state of things was still the effect of American competition, a big sale of Lake copper—about 9000 short tons at 9c., the lowest price on record—having scared holders in London into a realization. G. M. B.'s touched

£39 6s. 3d., and after a transitory rally to £40 1s. 3d. closed very flat at £39. In Birmingham a better demand for English copper had been experienced, as also from the Continent, chiefly for electrolytic copper.

June brought a further stage in the decline, G. M. B.'s ultimately touching £37 17s. 6d., the lowest on record, save during the panic period immediately following the crash of the syndicate. Refined copper remained slow of sale, despite the pressure of offers, and American production and exports, though less heavy than they were, continued on a large scale. At the low level above named, a little buying took place which raised G. M. B.'s to £38 10s., but part of this gain was lost before the month closed. Tough copper was now quoted at £40 10s.; best selected at £41 5s.; "strong" sheets at £48; India sheets at £46; and yellow metal squares at 4⅜d.

July opened with more life and a considerable improvement in prices, not only on the speculative market for G. M. B.'s but also in the market for consumption, and large sales of refined copper were made to the Continent. In G. M. B.'s the reaction found expression in an advance to £39, but unfavorable news from the United States as to prospects of tariff reduction caused a relapse, and this checked the consumptive demand. The sales of G. M. B.'s were rather heavy, and the month closed at £38 2s. 6d.

August brought at length a tangible improvement in the aspect of the copper market. The most prominent factor in the reaction—which was not checked even by the large sales by America of forward copper, including 10,000 tons of Lake at 9c.—was the passing of the United States tariff bill through Congress, leading to anticipations of a better consumptive demand there and smaller exports to Europe. With this were coupled rumors of negotiations for a fresh combination among the producers for the restriction of output; while the war between China and Japan gave promise of a demand for war material. The outside public, stimulated by these circumstances, began to interest itself in the article once more, and the result of the good speculative buying which ensued was a rise in G. M. B.'s from £39 10s. to £40 11s. 3d. To India a large quantity of manufactured copper was sold at a good advance in prices.

September was a period of comparative quietude among consumers in Europe and in India also; but the firmness of American advices respecting improved consumption, the advance to 9.75c. for Lake, and the continued negotiations among producers for restriction of output, all combined to render the London market firm. Considerable transactions took place in G. M. B.'s, the value of which rose to £42 1s. 3d., but this high level induced realizations which caused a relapse to £41 7s. 6d.

Early in October a momentary political scare in connection with Madagascar affected our stock and metal exchanges and caused a transitory relapse in values, but the rumors proving baseless the market recovered quickly, and £41 12s. 6d. was done for spot cash G. M. B.'s, a sharp rise in Rio Tinto shares occurring simultaneously. Later, the lack of confidence, and uneasiness felt in financial circles owing to the dangerous illness of the Czar of Russia was reflected also on the Metal Exchange, where a fall of about £1 per ton took place, followed by a partial rally near the end of the month.

November opened dull, with a scarcity of speculative buying orders, and with

consumers living from hand to mouth, pending a more stable state of affairs. America was just now not exerting any marked influence on the market, her offers being limited, while her shipments were quite moderate in extent. The G. M. B. market, under these conditions, was steady but inanimate, with "spot" ruling at about £40, until the third week, when realizations caused a fall to £39 11s. 3d. A rally to £40 6s. 3d. was induced by reports of improved consumption in America, but the month terminated with a fresh relapse to £39 15s. on somewhat persistent selling. The statistics for the second fortnight of November showing a decrease of 541 tons, there was some moderate speculative buying, which resulted in an improvement to £40 7s. 6d. during the first week of December, and to the establishment of a distinctly firmer and more hopeful feeling, which was further stimulated by the strong advices from America. In the speculative market a strong demand set in and induced a rise in G. M. B.'s to £41 1s. 3d. spot cash. A reaction which then ensued took the value back to £40 13s. 9d., and the market, being disturbed by the Christmas holidays, was very quiet, and closed on Dec. 29 at £41 3s. 9d.@£41 5s. spot, and at £41 11s. 3d.@£41 12s. 6d. three months.

The final values of refined sorts are as follows: £43 5s.@£43 15s. for tough qualities; £44@£44 10s. for best selected. Manufactured is quoted at £51 10s. for "strong" sheets; £48 for India sheets, and 4¼d. for yellow metal squares.

The Board of Trade returns give the imports and exports of copper in Great Britain as below, in tons of 2240 lbs.:

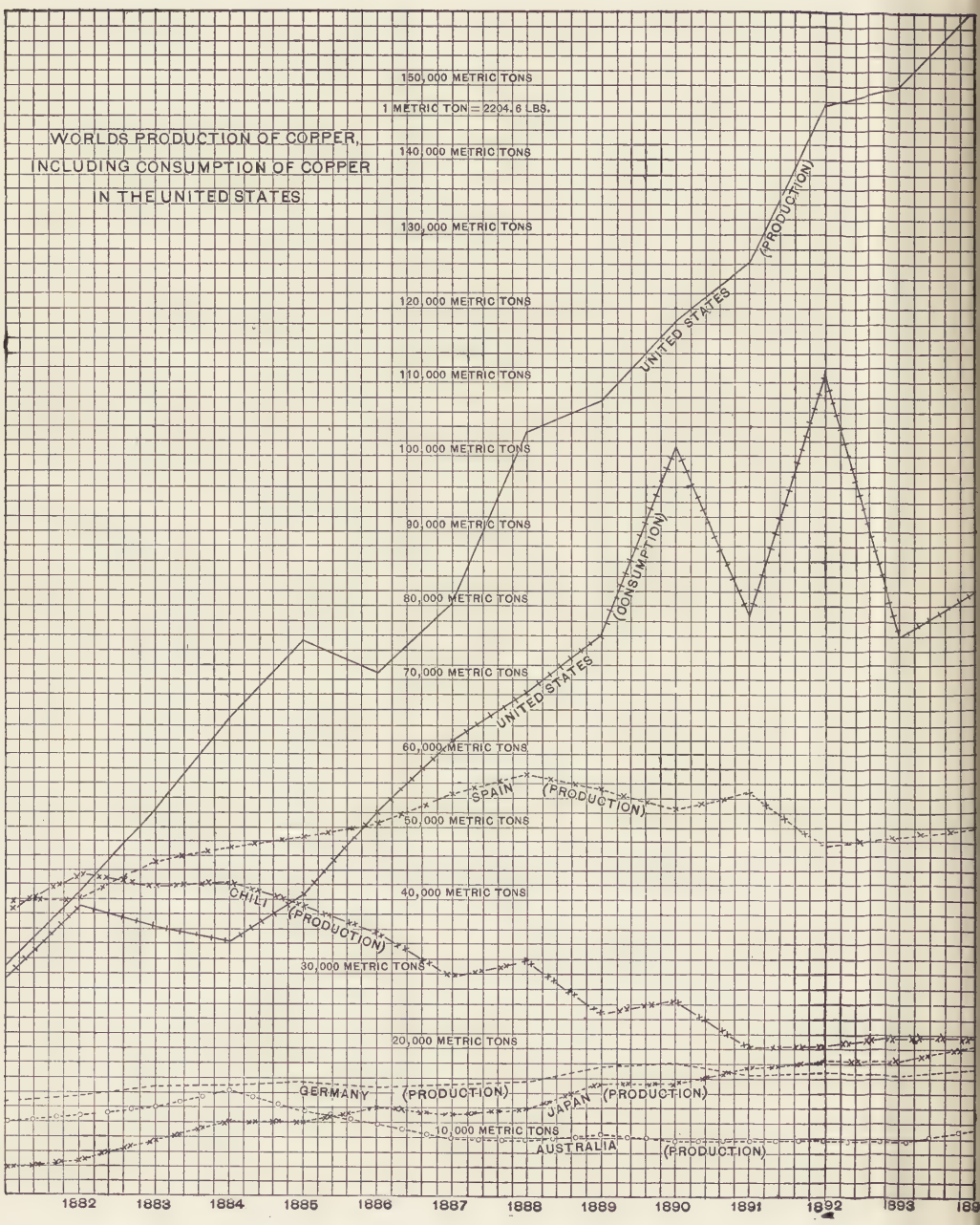
Year.	Copper.	
	Imports.	Exports.
1891.....	138,990	76,055
1892.....	134,808	82,540
1893.....	132,648	70,983
1894.....	129,602	54,689

The range of prices for five years past has been as follows on the London market:

PRICES OF G. M. B. BARS IN POUNDS STERLING PER TON OF 2240 LBS.

Year.	Stocks, Tons.	Jan. £	Feb. £	Mar. £	April. £	May. £	June. £	July. £	Aug. £	Sept. £	Oct. £	Nov. £	Dec. £	Year. £
1890.....	65,636	48⅞	47	47½	49⅛	54½	58½	57	60¼	59⅛	58½	55½	53½	54.125
1891.....	57,420	52½	52⅛	52.4	52½	52.2	53¾	54	52.4	52½	49¼	45¼	45¼	51.600
1892.....	55,462	44⅝	44¼	46¼	45⅝	46⅜	44⅞	44⅞	44⅜	44⅛	45⅝	47⅞	46⅞	45.125
1893.....	47,295	46⅛	45¾	45⅝	45	43¾	44	43	41½	42⅝	42⅛	42⅝	43¼	43.750
1894.....	54,664	41½	41	40¾	39⅞	39⅝	38¼	38¼	39⅞	41⅝	40⅞	39¾	41¼	40.198

During the past 30 years the highest average attained was in 1866, when it was £82 17s. 6d. per ton; this level was nearly reached again in 1888, with an average of £82 7s. 6d. The lowest average for any year previous to 1894 was £40 10s. in 1886.


WORLDS PRODUCTION OF COPPER, INCLUDING CONSUMPTION OF COPPER IN THE UNITED STATES
1 METRIC TON = 2204.6 LBS.
150,000 METRIC TONS
140,000 METRIC TONS
130,000 METRIC TONS
120,000 METRIC TONS
110,000 METRIC TONS
100,000 METRIC TONS
90,000 METRIC TONS
80,000 METRIC TONS
70,000 METRIC TONS
60,000 METRIC TONS
50,000 METRIC TONS
40,000 METRIC TONS
30,000 METRIC TONS
20,000 METRIC TONS
10,000 METRIC TONS
UNITED STATES (PRODUCTION)
UNITED STATES (CONSUMPTION)
SPAIN (PRODUCTION)
CHILI (PRODUCTION)
GERMANY (PRODUCTION)
JAPAN (PRODUCTION)
AUSTRALIA (PRODUCTION)
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894

Surface and Underground Practice at the Mines of Butte, Montana.

By R. G. Brown.

In introduction it may be said that the field is so large and the practice so varied that this paper must be confined to the more important properties.

Hoisting Engines.—The last few years have seen a great improvement in engines for hoisting purposes, until now scarcely one of the well-known makers escapes representation. No attempt will be made in this article to touch upon other than first-motion engines.

TABLE OF FIRST-MOTION HOISTING ENGINES IN BUTTE.

All duplex, with two reels and post brakes; also for flat rope, except where noted.

Mine.	Company.	Size Cylinders, in.	Style of		Maker.	Remarks.
			Brake.	Clutch.		
Alice	Alice	18 x 48	Hand	Jaw	Fraser & Chalmers	
Anaconda	Anaconda	20 x 60	Hand	Jaw	J. P. Morris	* Two engineers per shift.
Buffalo	"	20 x 60	Hand	Jaw		* Two engineers per shift.
GreenMountain	"	18 x 48	Hand	Jaw	Dickson	
High Ore, No. 1	"	20 x 48	Weighted	Jaw	Chicago Iron Works	Corliss valves.
High Ore, No. 2	"	20 x 48	Weighted	Friction	Webster, Camp & Lane	Corliss valves and governor.
Mountain Consolidated No. 2	"	20 x 48	Weighted	Friction	Webster, Camp & Lane	Corliss valves and governor.
Never Sweat	"	20 x 48	Weighted	Friction	Dickson	Corliss valves and governor.
St. Lawrence	"	20 x 60	Hand	Jaw	Prescott, Scott & Co	* Two engineers per shift.
Leonard Shaft	Bost. & Mont. Co	19 x 48	Weighted	Jaw	E. P. Allis Co	Poppet valves.
Mountain View	"	18 x 48	Weighted	Jaw	E. P. Allis Co	Poppet valves.
Pennsylvania	"	19 x 48	Weighted	Jaw	E. P. Allis Co	Poppet valves.
Gray Rock	Butte & Bost. Co	20 x 48	Hand	Jaw	Chicago Iron Works	Corliss valves.
Silver Bow No. 1	"	16 x 42	Hand	Jaw	E. P. Allis Co	Corliss valves.
Colusa-Parrot	W. A. Clark	16 x 30	Steam	Friction	Montana Iron Works	Corliss valves and governor.
Gagnon	Colorado Co	22 x 36	Hand	Jaw	Dickson	Drums and round rope.
Parrot	Parrot	20 x 60	Weighted	Jaw	Fraser & Chalmers	Slide valves.

* One for clutches and brakes and one to run.

There is a wide divergency in the size of cylinders in use, 20 by 60 in. being the largest, and 16 by 30 in. the smallest. This latter engine, however, is operating under different conditions from the others: only one of the two reels is used directly for hoisting, the other carrying a dead counter-weight running in the pump compartment of the shaft, so that the case approaches that of ordinary elevator practice. According to this arrangement the engine is doing about the same work in hoisting the counterbalance when the cage goes down as it does in hoisting the load on the up-trip. Cylinders 18 or 20 in. by 48 in. are the standard size, only one of the larger engines, that of the Parrot, being of recent construction. The large hoists of the Anaconda Company are old-fashioned and inconvenient, requiring two engineers on a shift to operate them, one attending to brakes and clutches and the other to hoisting. Although the attempt is made to run with balanced cages as much as possible, this is by no means always practicable, so that one cylinder must be able, unaided by the weight of the other cage, to lift the whole load. This load would roughly be 3½ tons, including 1000 ft. of cable, with single-decked cages, or 5 tons with double decks. Of these weights, ore can be held to make up 1 and 2 tons, respectively. This emphasizes the importance of balanced running.

Indicators are of two types, dial and spiral-barrel; the latter occurs only at the Parrot mine. On the old Anaconda hoists spiral dials are seen, in which the

hand makes several complete trips around, but at an ever-changing radius. The High Ore No. 1 engine has two hands on its dials, one standing idle till caught up by the mechanism a short distance from the top and then making a complete revolution back to the landing mark, thus affording a very accurate register of the position of the cage at the most critical time.

Poppet valves have been great favorites in the past, but Corliss gear is growing in popularity, as shown by the fact that the six Corliss valve engines in the table have all been erected since 1890, and four of them during 1894.

Governors are an innovation of the year 1894, but of the three governed engines listed only one is at the present writing (December, 1894) in operation, viz., the 16 by 30 in. at the Colusa-Parrot mine ; the others are in running order, but not yet at work. Experience with this engine, however, has shown that the governor, though seldom seen on hoists in the West, is of the greatest value as an economizer of steam. An additional feature of this engine is a device to increase speed, if desired, at any moment, by the mechanical addition of weight to the center of the governor. Here also we find a steam brake, with oil cataract, so arranged that in case of the failure of the steam from any cause the brake can be worked by hand. While this is not so ideally perfect as the weighted brake, it is practically a very satisfactory device.

Finally, engineers of first-motion engines work universally on 8-hour shifts, with wages of $4 a day; thus for an ordinary hoist with 250 horse-power boilers the labor sheet would be, for 24 hours: Three engineers at $4 each, $12; two firemen at $3.50 each, $7—total, $19.

Boilers and Fuel.—The return flue multitubular boiler is the universal type, and the common pressure from 85 to 95 lbs. Exceptions to this are the two boilers with double returning flues at the Leonard shaft of the Boston & Montana Company, which carry 125 lbs. and are used for special pumping work, and the forced draft boilers with safety tubes over the fire-box at the Silver Bow No. 1 shaft of the Butte & Boston Company, which draw though a brick stack. There is a central boiler station on the west end of the Syndicate (Anaconda) properties, supplying steam for the Mountain Consolidated and Buffalo mines. This is located about midway between the two hoists and perhaps 175 ft. from each. Similarly the Never Sweat takes its steam from the Anaconda hoist 500 ft. away, through the medium of a pressure cylinder close to the engine.

Coal is somewhat slowly replacing wood as a fuel, the Anaconda Company, Boston & Montana, and Parrot still using the latter. The favorite coal is the Rock Springs of Wyoming. The slack from these mines is laid down on the switches at Butte for $3.50 per ton, and the best quality is a clear-burning clean coal. For the burning of such fine material there are several designs of small-meshed grate-bars in use, but mechanical stokers, or any of the mechanical devices for supplying fuel or removing ashes are not seen; perhaps they could hardly be looked for until the largest plants give up burning wood. It can be assumed that, under ordinary conditions, one ton of Rock Springs slack coal will raise 75 tons of material (ore or water); this will give 13 tons of coal for each 100 tons raised, or, taking coal at the mines at $4, 5⅓c. per ton of material raised. This figure, be it remembered, represents, as nearly as possible, medium conditions of depth, water, condensation, etc. In the majority of cases coal is

hauled by team from the nearest switch, either directly from the cars, or from a private coal shed, as for the Clark properties. The users of wood are for the most part equipped with supply switches connecting with one or other of the railroads, but in many cases the wood has to be again moved a hundred feet or so from the track to the boilers, which is done by hand-truck or team. The price of wood, though varying, can be placed roughly at $3.50 per cord, f. o. b. at Butte. Firemen are paid $3 to $3.50 for 12 hours, and one man feeds of from 250 to 300 horse-power of boilers.

Gallows Frames.—There are three varieties common, which can be classified by the disposition and number of the main timbers, the minor bracing being diverse. *a.* Those with two vertical posts and two braces toward the engine, being the simplest in form and the natural development from the informal constructions of small mines. *b.* Those with four inclined posts replacing the two vertical ones, two slanting toward and two away from the engine, and two braces as in *a.* These are designed for especial steadiness. *c.* Those with four vertical posts and two braces, copied from the pit-mouth frame of coal practice. The first (*a*) is the most common and cheaply constructed, and the favorite with the Boston & Montana, Butte & Boston, and Clark mines. The second (*b*) is more expensive and is the specialty of the Anaconda and Syndicate mines. The last (*c*) is seen in its most massive form in the Parrot hoist, where it fairly dwarfs the large building. Frames run from 40 to 60 ft. in height. Sheaves are generally of cast iron, though there are a few with wrought-iron arms.

Chairs.—Landing chairs are used everywhere, the most approved form being arranged so that they can be pulled from beneath the cage and thus avoid the delay of lifting the cage from them by the engine preparatory to lowering. They are all of the tongue-type: hinged about 2 ft. below the collar, with the tongues projecting up, so that the cage rests on their ends.

Cages.—Double-decked cages are in use at most of the larger mines. There are two devices for holding the cars in place on them: guards swinging down over the ends of the car, and hooks catching into eyes on the sides of the car. The latter is the Anaconda practice. Safety devices are of the eccentric-dog type, held open by discs, with chains attached to the king bolt and closed by flat spiral springs. The Gagnon mine (Colorado Company) uses a skip, its shaft being an incline. The only unusual feature about this is that the weight of the cross-head is carried by small wheels running on the guides, thus avoiding the considerable wear of a flat shoe on them and making the skip run much more smoothly. The load carried is one mine-car full. Two other shafts, the Stewart and the Speculator, are inclines and use skips, the Stewart being arranged to dump ore directly into the bins. There is also a fourth incline, the Original, using a cage carried on the guides by broad flat wheels—a very successful device.

Ore Handling.—Handling of mine cars around shafts is invariably on iron plates and not on tracks with switches, and frequently the cars have to be run some considerable distance to dump. The Colusa-Parrot mine (W. A. Clark) is most conveniently arranged for this, the chutes being in front of and but 15 ft. from the shaft. Next to this in convenience is the Parrot.

The shipping of ore can be best considered under the classification of the companies. The Anaconda and Syndicate properties, with scarcely an excep-

tion, ship by rail, a road having been recently built between the smelter at Anaconda, 26 miles from Butte, and the mines, for this traffic, although passenger trains are run as well. This line, the Butte, Anaconda & Pacific, supersedes the Montana Union line, which for several years performed the same office. The result is that, as the mines are by no means closely bunched, the hills above Butte are greatly cut up by the various spurs and switchbacks of the two lines. It is a favorite practice with this company to hoist to tunnel-level, 40 to 50 ft. below the collar of the shaft, and run the ore thence in mine cars to the railroad chutes, often a distance of several hundred feet. In one case only is other than man-power used; at the Green Mountain trains of four cars are hauled by mule 400 or 500 ft. to the chutes. Long running of this kind calls for three topmen at least per shift, and with a large output double that number.

The Boston & Montana Company also ships by rail, its ore going over the Great Northern road to the smelter at Great Falls, a distance of about 150 miles. Tunnel-level exit is not practiced by them. In the case of both of these companies the chutes are high-posted and covered, and the loading is by gravity through iron nose-pieces, the flow of ore being regulated by gates with rack and pinion mechanism. The cars used are bottom-dumping, ballast cars, with a nominal capacity of 30 tons.

The Montana Ore Purchasing Company also ships by rail from the Glengarry No. 2, about half a mile. The Parrot has facilities for shipping equal to those of the others, as there is a narrow gauge gravity road from the mine to the smelter, 1¼ miles, the empties being returned by horses.

The Butte & Boston Company ships by car and horse from the Silver Bow No. 1, running directly over a trestle to the concentrator, about 700 ft., while from the lower shaft (No. 2) the ore is hoisted to the same place on a short incline of 250 to 300 ft. Other properties of the Butte & Boston, and other companies, as well as individuals, ship by quartz-team, 5 tons being a full load for four horses over fair roads, the grades being in favor of the load. The distances hauled would be roughly, for the Butte & Boston Company, from Gray Rock, 2½ miles; from Blue Jay, 1 mile; for the Boston & Colorado Company, 2 miles; for W. A. Clark's properties, 2 miles—rate about 25c. per ton per mile.

The principal silver companies, which are at present idle, the Moulton, Alice, and Lexington, have their own mills close at hand, and ship directly by mine-car—the Moulton 200 ft.; the Alice 150 and 500 ft. to the old and new mills respectively, with 2000 ft. additional to be added for ore from the Magna Charta, which is hoisted through a separate shaft and trammed over a long trestle; the Lexington 700 ft.

Rope Weaving.—Flat ropes being universally used on first-motion engines (the Gagnon stands as an exception, having an inclined shaft) means for their repair are provided by most of the companies. The factory lacing is not held in high esteem, and after a few months' run a rope is generally ripped and relaced. Further, it is the lacing that wears most from friction on the reel arms and sheave flanges, and the rope strand, if cared for, will outlast several relacings. On this work the larger companies keep a ropeman busy much of the time. The process is complicated and does not admit of a simple description, but the apparatus used will be interesting to note. It consists of two large reels, mounted on

trucks, one at least of which can be wound up by means of a gear and pinion, and has a brake; a long room with narrow bench down its center; a boiler-iron tank, with double steam bottom, set on flat wheels, and dimensions roughly 20 ft. by 10 in. by 15 in., for cleaning old cables before ripping. Besides these there is a small crank device for twisting the lacing, and old quicksilver flasks for weights to give each of the strands the same tension. The lacing wire used is of Norway iron, 16 or 18 gauge, according to the size ofthe rope. A steel wire is at times used, but is not to be recommended. Weaving flat ropes costs about 10c. per foot, one ropeman and helper lacing commonly 75 ft. a day. Facilities being thus at hand, new ropes are frequently made, the strand, of English crucible steel and already twisted, being bought from the dealers. Sizes of rope run from 4 in. by $\frac{3}{8}$ in. to 6 in. by $\frac{5}{8}$ in., the common size being 5 in. by $\frac{1}{2}$ in. The round rope used by the Gagnon mine in its inclined shaft is the "locked" rope of the Trenton Iron Works, its smooth surface making it very serviceable in cases where there is much surface wear. The best protection against the exceedingly corrosive water of the copper mines is considered to be a mixture of pine tar and tallow, put on hot, the proportions being 5 to 8 gals. tallow to 1 barrel of tar. Manufactured cable coatings are somewhat used, but as a rule are not sufficiently penetrative for use where much water is present.

Compressors.—Machine drills are by no means so frequently used as would be expected from the size of the deposits, but as cheapened production becomes necessary they will be in more demand. At present the Parrot Company is the only one of the large producers not using machines at all. Rand compressors have been the most popular, but there are one or two of Ingersoll make in use, and a large Ingersoll-Sargeant is shortly to be erected at the Mountain Consolidated. There is an E. P. Allis compressor, with Corliss valves, at the Mountain View, and two or three Burleighs at the Syndicate mines.

Blacksmithing.—There are no features to note of especial interest. One blacksmith and one helper can sharpen the tools of 60 to 65 miners, including those for half a dozen machine drills, at a cost for wages of $4 for blacksmith and $3 for helper, or $7 per day.

Timber Framing.—The veins of Butte being preëminently large, square sets are universally used. This makes the framing of the timbers a matter of great importance. Very elaborate machines, built by Hendey & Meyer, are used for this purpose by the Gagnon mine (Boston & Colorado Company) and Clark's properties. These are arranged to frame both ends at once, and to completely finish a stick in twice running through the machine. Elsewhere a simpler machine is used, built by the Montana Iron Works of Butte, which frames but one end at a time and takes four cuts to finish a stick. This style of machine is the favorite of all the other companies, notwithstanding that it slightly increases the cost for labor. On the other hand there are fewer saws to sharpen and less time is taken in setting them.

In some of the Anaconda mines the framing is done more simply yet by a single small circular saw. Wedges are cut from 2-in. blocks by a larger saw with beveled guide for the block, and the framing-room is further equipped with a swinging cut-off saw, drawn through the stick by the operator, or pushed by a rack and pinion device. This latter is peculiar to some of the Anaconda works.

Sawed timbers of sizes from 8 to 12 in. square, are used for framing. The Gagnon is the single exception to this, using round timber for all but sills. The general design of square sets in use gives short-tenon posts, long-tenon caps, abutting each to each, and short-tenon girts. Both ends of all timbers are framed alike and only the girts are unsymmetrical, being unframed at top and bottom. Two hundred and fifty to 400 sticks are turned out by two men on a framing machine in a day of ten hours, the personal factor of the men, as well as of the machine, being accountable for the wide margin of variation. The minimum force for the framing-room would be one man at $4.50 per day and one man at $3, or in all $7.50. This would be indefinitely increased according to the conditions of the particular mine.

Miscellaneous Features: Diamond Drill Holes.—Fire still lurks in the old workings between the Anaconda and the St. Lawrence mines, vestiges of the disaster of 1889, and a great many drill holes have been put down, from the surface over this region, through which water is being run into the mines. These holes at present number over thirty. Surface manifestations of the existence of the fire appear in the copious steam and sulphurous fumes coming from certain old shafts, as well as the cracked surface due to the wasting of the smoldering materials below. As a direct result of this pouring of water through oxidizing sulphides the water pumped from the St. Lawrence is a strong solution of copper sulphate, and has been profitably leased for several years past. It is passed through consecutive tanks over scrap iron and a portion of the copper saved as cement. The percentage of copper in the water varies, but can be taken as 0.4%. This is the extreme case, but the water of most of the copper mines contains more or less copper, which it is attempted to save by the companies or lessors.

Water Hoisting Tanks.—Many of the mines have these on hand for emergency. They are of boiler iron, square, and running on the guides in place of the cage. There is an inlet poppet valve in the bottom, and an outlet clack valve on the side operated by a lever at the top. The tanks at the Anaconda mine are 3 ft. by 3 ft. by 10 ft., holding 675 gals. of water, or about 2½ tons; this would make not far from 5 tons starting weight at a depth of 1000 ft. Tanks of about half this size have been in use at the Silver Bow Shaft No. 2.

Parrot Air Tops.—At the Parrot mine there are two air tops over the two air shafts. These being down-takes the tops are devised to catch all the air possible, and further, to take advantage of any breeze there may be. This is accomplished differently by each of the tops. In one by having double doors, with flaring portals on the four sides of the structure, these being opened on the proper quarter to catch the wind; in the other by the use of a revolving turret, with one flaring portal which can be turned toward the coming wind. Both tops are of corrugated iron on an iron frame, to obviate danger from fire. As an aid to the uptake, and also to keep the fog from the shaft from filling the shaft-house in cold weather, this mine has a hood of wood built on to the gallows frame a short distance above the collar and reaching through the roof. The effect is admirable. Several other mines have similar but less complete arrangements.

Cornish Pumps.—These have never been popular and are to be found only in two of the silver mines, the Moulton and Alice, adjoining properties on the "Rainbow Lead." That at the Moulton is operated by a single 24 by 48 in.

cylinder, and gives an 8 ft. stroke. The bob is of cross-braced iron. The Alice pump has a 22 by 48 in. cylinder and an 8 ft. stroke. The bob is of solid iron girders.

Cost of Supplies.—The following table shows the comparative prices, in the years named, of the various supplies in common use around the mines, prices being for goods delivered at mines:

PRICES OF SUPPLIES AT THE BUTTE MINES.

Material.	1885.	1890.	1894.
Powder, 40%, per 100 lbs	$29.50	$19.75	$11.50
Caps, per box	1.00	.75	.65
Fuse, per case of 6000 ft., triple-tape	54.00	36.00	38.00
Candles, 16 oz. per box	7.00	4.75	4.75
Drill steel, per lb	.18	.11	.08⅓
Iron, common, per lb	.04¼	.03⅛	.02¾
" Norway, per lb	.07	.05½	.05
Pipe, 3-in , per ft	.42	.....	.25
" 5-in., per ft	.....	.73	.50
Lumber, per 1000 ft	20.00	15.00	12.00
Stulls, 6 to 12 in. in diameter, 16 ft. long; per inch of diameter	.10	.10	.09
Lagging poles, over 2 in. in diameter at small end, 16 ft. long, each	10	.09½	.08⅓
Wood, per cord	5.00	5.00	4.50
Coal, per ton (2000 lbs.)	.....	.....	4.75

The mines of Butte have been of such phenomenal richness—speaking only of the copper mines—that not until the last few years has there been much of that necessity which is the mother of invention. The rates of wages have not changed much during the last ten years. Not many years ago Butte had no practice worthy of the name; to-day she has one that is most instructive and constantly improving.

Work in the Butte Mines in 1894.

The record of the year in Butte is principally of copper mining, as the silver mines can scarcely be said to have been in operation. It is true that the Lexington and the Alice silver mines have been working tributers, and that here or there a mine has been kept open, but, except in the case of small leasers, such work has not been done for profit, but rather to save the mines from falling into hopeless ruin. The silver mills have been kept running much of the time on custom ores from leasers, but at the end of the year the Moulton alone is found with its stamps dropping.

The Butte copper belt has its length to the east and west, and is fully twice as wide on the eastern end as on the western. Its dimensions are roughly two miles long by half a mile wide on its western end and a mile and a quarter on its eastern. The important companies operating are given in alphabetical order, as follows: Anaconda, including the Chambers' Syndicate; Boston & Montana; Butte & Boston; W. A. Clark; Colorado Company; Montana Ore Purchasing Company; Parrot Company; Washoe and Gold Hill (not yet a producer).

In the following table is given the principal mines of each of these companies, with their present depths, and the feet sunk during the year 1894. As the point to be established is the various horizons of development, these are designated by their familiar names, though by far the greater number operate through a single shaft several adjoining claims.

DEPTH OF SHAFTS, BUTTE MINES, SHOWING PROGRESS MADE IN 1894.

Mine.	Total Depth.	Sunk in 1894.	Mine.	Total Depth.	Sunk in 1894.
Anaconda Company—	Feet.	Feet.	Butte & Boston Company—	Feet.	Feet.
Anaconda	1,200	.....	Blue Jay	450	200
Buffalo (Mountain Consolidated No. 1)	900	.....	Gray Rock	1,300	100
Green Mountain	1,000	.....	Silver Bow No. 1	900	100
High Ore No. 1	1,200	.....	Silver Bow No. 2	700	.....
High Ore No. 2 (not a producer)	600	400	Colorado Company—		
Modoc	1,000	400	Gagnon	1,200	.....
Mountain Consolidated No. 2	800	300	Montana Ore Purchasing Company—		
Never Sweat	800	.....	Glengarry No. 2	600	150
St. Lawrence	1,100	.....	Parrot Company—		
Boston & Montana Company—			Parrot	900	.....
Leonard	600	.....	Miscellaneous—		
Mountain View	1,100	100	Gambetta	575	.....
Pennsylvania	600	.....	Poulin	400	.....
West Colusa	600	.....	Rarus	600	.....
W. A. Clark—			Speculator	525	100
Colusa Parrot	800	100			
Original	800	.....	Total for all productive mines	21,050	1,950
Stewart	400	400	Total ore-extracting depth for 1894	19,100	.....

There are 26 properties named in this table, with an aggregate shaft depth at the end of the year of 21,050 ft. Sinking in 1894 amounted to 1950 ft., or 75 ft. per shaft. Ground sunk through this year has certainly not been robbed of its ore as yet, so that by subtracting 1950 from 21,050 we fairly arrive at the aggregate of the ore-extracting depths of the mines—19,100 ft. Alone this figure means nothing; its significance appears in what follows.

Copper ore is to-day being extracted from the 1200-ft. level in one mine at least, so that the presence of pay ore at that depth can be held as assured. When all of the 26 mines have reached that mark they will aggregate 31,200 ft. of shaft. Between that future aggregate and the present there is a difference of 12,000 ft., which, at the present rate of say 2000 ft. per annum, will not disappear for six years. It must be clearly understood that no one conversant with the conditions and facts can believe that six years, or ten years, will see the last of the valuable Butte ores, either as to quality or quantity. The above deduction is made simply to afford some basis for estimate other than mere opinion. As a matter of fact, while it is certain that the Butte copper ores are the result of natural concentration, and that with depth the deposits must turn from the characteristic blue to yellow sulphides, the horizon of this change is not in sight, even at the 1200-ft. level. In more than one case yellow sulphides have predominated at a comparatively shallow depth, only to give place to the blue ores again below.

One important factor in the question remains to be touched upon, and that is the prospect for the development of new properties, and the enlargement of the productive area. For the purpose of a general view the copper mines may be classed in three systems: The Northern, extending from the Modoc on the east to and beyond the Buffalo on the west, and including the Speculator, High Ore, Gray Rock, Green Mountain, and Mountain Consolidated; the Middle, extending from the Leonard on the east to the Gagnon on the west, and including the Mountain View, Anaconda, St. Lawrence, Never Sweat, Colusa-Parrot, Parrot, Blue Jay, Washoe, Stewart, and Original; the Southern, which spreads out to the southeast and includes the Silver Bow, Pennsylvania, Glengarry No. 2, and others. The greatest enlargements of productive area have of

late come from the third division, and it has already yielded considerable ore. Development work is now being prosecuted with considerable success, while more than one lode in this region lies unworked because of conflicting interests in its ownership. On the extreme western end of the first system developments are in progress on the Oro Butte claim by the Parrot Company, and on the Yellow Jacket by the Anaconda Company, while the success of the Butte & Boston Company in its work on the Blue Jay in the second system has prompted the sinking of two new shafts on the Washoe and Gold Hill claims. Indeed, it may fairly be assumed that a year or so more will see the actually productive area increased by a third of its present size.

Nor is it the fact here, as it so often is elsewhere, that the ore deposits lessen in size with depth; quite the contrary, for it has been the exception to find the large stopes in the upper levels. The reason for this cannot be given until the district has had the study it deserves. But it is a fact which becomes all the more striking when compared with the great "blow-outs" of the silver veins to the north.

The cost of mining may be taken at present as under $3 a ton, falling in isolated cases to $2; a small decrease may be expected in this, from the more general use of machine drills and from improvements in steam economy. The governor engine will play a part in this, and possibly central boiler plants. Co-operation as to pumping and sundry other matters might effect some saving, but is not to be expected. Three-quarters at least of the mining expense lies in the labor, and no change is to be expected in this, except in the increased efficiency of the miner due to improved mechanical devices. A few other notes of cost may not be out of place, as representing about the average of good practice. Ordinary drifting, or cross-cutting, in or near the ledge, with machine drills, costs $4.50 a linear foot, where each foot of advance represents a little over 2 cu. yds. of rock. In sinking, $30 per foot may be counted for a three-compartment shaft, where each foot represents something over 4 cu. yds., the men being on three 8-hour shifts and machine drills being used. The bare labor of stoping, that is mining and shoveling, would be covered by about $1.60 to $1.80 per cu. yd., say 2½ tons of solid ore; this with machines and in 6-ft. stopes or wider. The above figures are for labor alone, and are given to afford the experienced some idea of the character of the rock and ore. Away from the vicinity of the veins the granite is often of the hardest, and may cost $20 a linear foot to drive by hand. Wages for miners are $3.50 per day.

It is not possible to give in much detail the work of the mines for 1894, but some points as to development and equipment can be given.

Anaconda Company and Chambers' Syndicate.—The Modoc, having been stopped at the 600-ft. level for several years, has been pushed down to the 1000-ft., and the Mountain Consolidated has gone from the 500 to the 800-ft. The High Ore No. 2 shaft has been sunk 400 ft., and is now at the 600-ft. level. It is the expressed intention of the company to sink this shaft continuously for some time to come, the present engine having a capacity of 1800 ft., and a final depth of 3000 ft. or more being spoken of. This shaft is sunk on the Deadman, and is intended to serve for the deepest development of the properties to the north, which will approach it on their dip. It will not be used at present for

raising ore. The shaft-house here was burned in the fall, just as the new engine was ready for use, and work was only started again just at the end of the year.

New engines have been placed on the following properties: Never Sweat, High Ore No. 2, High Ore No. 1, and Mountain Consolidated, all of these with Corliss valve gear, and three of them with automatic governors. Ore-chutes are being erected at the Never Sweat, and this is to be the main hoisting shaft of the Anaconda mine, the old shaft being used for lowering timber, etc. A 30-drill Ingersoll-Sergeant compressor is also being placed at the Mountain Consolidated. The company has made several additions to its properties, but chiefly of undeveloped claims, in the close vicinity of one or other of its possessions.

Boston & Montana Company.—The shaft of the Mountain View alone has been sunk; from the 1000 to the 1100-ft. level. Connections have also been made between this shaft and the Leonard on more than one level, through intervening ground owned by the company, a straight-line distance of 2500 ft.

Butte & Boston Company.—About 400 ft. of shaft work has been completed by this company during the year, from the 1200 to the 1300-ft. level on the Gray Rock, from the 800 to the 900-ft. on the Silver Bow No. 1, and from the 250 to the 450-ft. on the Blue Jay. This last property has been operated under bond for most of the year, but the developments have been encouraging, and the property has been purchased. The claim lies south of the main Parrot properties, and the exploiting of a valuable deposit here gives promise of workable ground still further south, where some strong outcroppings exist.

W. A. Clark Properties.—The Original mine has been closed at a depth of 800 ft. This was one of the oldest of the copper mines, and its shutting down can be accredited to the low price of silver. The silver values are much higher in the ores on the west end of the belt. The Stewart mine, which has been closed for several years, has been reopened, and a new inclined shaft has already been sunk 400 ft. The value of this property has long been beyond doubt, but various reasons have prevented its recent operation. The shaft of the Colusa-Parrot has been deepened to the 800-ft. level, and a first-motion engine, with Corliss valve gear and governor, added to its equipment.

Colorado Company.—The Gagnon is the copper mine of this company, and is the most western producer of the belt. At the end of the year sinking was completed to the 1200-ft. level. Power drills have been adopted for certain work of late, and a 14 by 22 in. duplex Rand compressor erected.

Montana Ore Purchasing Company.—Besides sinking the shaft of the Glengarry No. 2 from the 450 to the 600-ft. level, this company has been actively developing the Belmont and the Iduna. While work in the former of these has been disappointing, it is not yet given up. Of the latter it is too soon to speak. All of these claims lie in the Southern system, and the Glengarry No. 2 is the furthest outpost in the flat.

Parrot Company.—The company has added the Oro Butte, on the west end of the Northern system, to its list and has commenced development work on it. On the Parrot mine no sinking has been done. This group of claims still furnish the regular supply for the smelter.

Electrolytic Copper Refining.

By Titus Ulke.

We may conveniently divide electrolytic processes, as applied to copper ores, matte and metal, as follows:

1. *Extraction Processes,* or those chiefly treating ores and mattes, such as the Marchese, the Siemens & Halske (using a sulphate of copper and iron electrolyte) and the Hoepfner process (in which the electrolyte is a chloride solution), and

2. *Refining Processes,* which treat chiefly blister copper. Those in vogue all use a sulphate electrolyte, and may be classified as follows:

I.—Cathodes or anode faces serving as cathodes, flat and stationary:
  A. Systems with horizontally disposed anodes:
    (*a*) with screens.....Smith Process.
    (*b*) without screens.....Randolph Process.
  B. Systems with vertically disposed anodes:
    (*a*) plates in series.....Hayden Process.
    (*b*) plates in parallel.....Multiple Process (Thofehrn Process).
II.—Cathode, a rotating cylinder.....Elmore Process.
III.—Cathode, an endless traveling band.....Moebius Process.

To the information on Electrolytic Refining contained in The Mineral Industry for 1893, pp. 273–286, the following notes and criticisms should be added to bring the subject up to the present date:

Hoepfner Cupreous Chloride Process.—E. Jensch reports, in the *Chemiker Zeitung* of Dec. 5, 1894, on this process as follows: The Hoepfner process was in use at the Schwarzenberger Hütte in Saxony from August, 1891, until March, 1892, and also at the works at Giessen and Weidenau, near Siegen. The electrolyte used consisted of a solution of cuprous chloride in calcium chloride, instead of in common salt. Notwithstanding certain advantages of the Hoepfner process it was discontinued because of difficulties encountered. The ore treated was cupriferous pyrrhotite and pyrite of northern Norway. At Schwarzenberg only the richer sulphides, containing 9.5% to 12.3% copper, and from 98 to 56 grams of silver per ton, were worked. These sulphides were ground very finely, and then extracted in revolving wooden drums of 900 to 6000 liters capacity. To dissolve the copper sulphide, as before mentioned, a solution of cuprous chloride in calcium chloride was used, with the following reaction: $Cu_2S+2Cu\,Cl_2=2Cu_2Cl_2+S$. The chemical reaction of a hot solution of cupric chloride on cupriferous pyrites and pyrrhotite causes a portion of the iron to be dissolved, and on this account a much higher percentage of cupric chloride has to be used in the leaching solution than would seem necessary for the ore alone. Generally 50% of the copper in the ore was obtained in the first leaching, but the remainder could only be extracted with difficulty even after 10 to 12 leachings. This unsatisfactory result was caused by the high percentage of iron in the ore, the absorption of water by the calcium chloride and the consequent dilution of the solutions, and also by the inefficient evaporating and heating arrangements. It was necessary to heat the solutions passed through the filter presses to 40° or 50° C. to prevent loss of copper in the precipitated iron slimes. The anode and cathode cells were separated by a diaphragm of parchment enclosed in jute linen. The cathode consisted of thin copper plates of 0.25 sq. meters surface, and the anodes of paraffined

carbon rods. Owing, it is said, to the generation of free chlorine, which was evolved whenever the air current passed through the solutions was interrupted, or the electromotive force of the current exceeded 1 volt, the parchment diaphragms were softened, weakened, and easily ruptured. A mixing of the anode and cathode solutions frequently occurred, and as a result the daily copper output of the plant by the Hoepfner process was only 50% to 89% of the theoretic yield.

Treatment of Black Copper.—Ninety per cent. copper is refined electrolytically at Stefanshütte in Hungary. In the United States all efforts at electrolytically refining black copper (containing 75% to 92% Cu) as far as made known resulted in failure because of the difficulty and expense of producing pure metal from black copper. According to Dr. Elbs,* with a current density of 20 ampères per sq. meter, it takes 5 months to deposit electrolytic copper 1 cm. thick.

1	horse-power	in	24	hours	produces	74½	kilos	fine copper	from anodes of	99.5% to 99.6% Cu.
1	"	"				46	"	"	"	98 % "
1	"	"		"		25	"	"	"	95 % "
1	"	"		"		15	"	"	"	90 % "

This shows how rapidly the energy consumed rises, in consequence of the increase of the counter-electromotive force, with the higher percentage of impurities. The anodes dissolve not only at their surface, but in their interior, even when covered by much undissolved copper. Anodes of 96% copper, 2.5 cm. thick, and very brittle, become so soft, after only 10 days electrolysis, that they can be rolled together like thin pasteboard without breaking.

Smith Process.—This process consists in a horizontal arrangement of the electrodes, in series, and with filtering cloths placed between each layer. Although it has been claimed that a circulation of the electrolyte is not necessary in the Smith process, circulation tubes are generally provided. In loading a tank, a row of five anode plates are placed in the bottom of the tank and above these a filtering cloth, then another row of anode plates and another filtering cloth, and so on up to the top of the tank. Deposition takes place on the top of every anode plate and dissolution from the underside of every electrode. A thin coating of paraffine applied to the upper side of each plate prevents the deposited copper from being attacked after the blister copper has been entirely eaten away. The slimes fall on the filter cloths and are thus prevented from coming in contact with the deposited copper. The Smith process does not compare favorably in efficiency with other systems of electro-deposition, where the plates are in series, for the following reasons:

1. The slimes covering the filter cloths give these a certain conductivity. The cloths being in contact with the sides of the tank make possible short circuits around the tank, with the result that the efficiency of the current is greatly impaired.

2. As the anodes wear away, the contact points between the plates wear away also, and there comes a time when the plates may not be in contact at all; great heating will then take place, with a large loss of mechanical energy as a result.

* *Chemiker Zeitung*, Oct. 13, 1894.

3. The greatest defect of the Smith tank arrangement is that it does not admit of a personal examination of the progress of the work in each tank, as is the case with the ordinary series and multiple processes, and that it necessitates unloading of the tank in order to remedy any trouble. It obviously will not pay to unload a tank until it is ready, *i. e.*, until the deposition is entirely accomplished, and therefore the above objection is a most serious one.

Hugon Process.—This French process is almost identical with the Smith process, and like it, provides for catching the insoluble impurities on intercepting screens. The Hugon process has the following objectionable features: The screen is costly, augments the resistance of the bath about a quarter of a volt per plate (according to H. Fontaine), and does not always prevent the finest slimes from passing through it, and soiling the cathode. It frequently occurs that fragments of copper are detached from the anode when the latter becomes thin. These pieces fall on the screen, which bends down, and even touches the cathode, the screen then becoming in part inclosed by the deposited copper. The general arrangement does not permit matters to be remedied, as this would involve the removal of the overlying plates and interruption of the deposition. Of course, one can avoid this inconvenience by reversing the current, for the slimes now remain on the anode and a screen is then unnecessary. But then the following trouble begins. The anode covered with slimes is attacked with greater difficulty by the acid, and the solution soon becomes poor in copper. The acid, predominating, redissolves a part of the deposited copper, and proportionally reduces the normal copper output. These defects are largely overcome by the following arrangement.

Randolph Process.—Randolph's patent No. 514,275, of Feb. 6, 1894, refers particularly to that class of electrolytic vats in which the metal plates are horizontally disposed. In vats of this type, the space between the adjacent plates may be said to constitute a cell and, as heretofore practiced, all the impurities produced in these several cells settle on the bottom plate of each individual cell (unless, as in the Smith process, provision is made for catching the insoluble impurities on intercepting screens), or remain in suspension in the solution within the individual cells, with the result that when, as in the present case, the lower plate is made the anode and the upper plate the cathode (in which case the copper deposition takes place on the under side of the several plates), the impoverished solution, poor in copper, and holding in suspension more or less of the impurities or slimes, is retained against the under or cathode side of each plate. Under such conditions the action of the cell is not uniform, and the deposition of the metal is uneven, and the liability to deposit impurities is much greater on account of the aforesaid impoverished solution being against the cathode plate. Randolph remedies these defects by causing the electrolyte to circulate through the cells, whereby all impurities or slimes sufficiently light to be held in suspension and carried by the current are carried out from between the plates by the moving or circulating electrolyte and deposited elsewhere. Randolph's electrolytic vat has near one end a partition extending across the vat from side to side, and down to within a short distance of the bottom of the tank, a passage being left beneath the partition for the flow of the electrolyte from the large compartment of the vat, in which are placed the copper plates, under the partition, and into a small

end compartment, and from thence through an overflow orifice or outlet near the top of the end compartment into a trough leading to a settling tank. The electrolyte is pumped or elevated from the settling tank to the supply tank and, after purification, allowed to flow back into the vats. The horizontally placed copper plates in the vat are separated from each other by non-conducting strips or blocks, preferably of glass, porcelain, or other vitreous material placed between the successive plates at the corners, so as to support them in a pile or stack, the intervals between the plates being uniform for the entire pile and each plate insulated from all the rest except through the medium of the solution. The metal plates to be treated may be rolled, pressed or cast, although the best results are obtained by using rolled or pressed plates because of the greater uniformity of the surface and homogeneity of the metal. The positive and negative poles of the dynamo are connected with the bottom and top copper plates, respectively, of the series. The plates with their separating strips are a little shorter than the main compartment of the vat, leaving spaces thereby at the end for the free flow and circulation of the electrolyte. Arranged just above and a little to one side of the vat is a circulating or supply pipe, which has a valved branch pipe discharging into a foraminiferous-bottomed box just above and across the end of the plate apartment of the vat, and adapted to discharge the electrolyte into the end space of the vat, in a shower of drops, in order that there may not be a continuous fluid connection at any instant between the solution in the vat and the solution in the box, or the box itself and the supply pipe connected therewith. A similar broken flow for the electrolyte from the vat into the trough leading to the settling tank is provided for a like purpose. Thus in the above system an effective circulation of the solution is maintained, for which no provision has been heretofore made, the inventor claims, in systems with horizontally arranged plates. This new system prevents the accumulation or formation of an impoverished copper solution against the lower or cathode side of the plate, and avoids the presence of impurities held in suspension in close proximity to the cathode sides of the plate, thereby largely preventing the deposition of impurities with the electrolytic copper. The arrangement described does not, however, obviate the objection, common to all systems with horizontally disposed plates, of necessitating the unloading of the tanks if one wishes to examine the plates or to remedy any serious trouble.

Elmore Process.—This process, which aims at electro-refining impure copper and at the same time producing a tube or other complete industrial product, has not proved a success. The tubes so made, when heated, are said to exfoliate. Klein has sought to remedy this, by substituting for the agate compressor or hammer, rolls of glass, porcelain, or similar hard acid-resisting material, which act against the cylinder on which the cathode copper is being deposited and compress the latter.

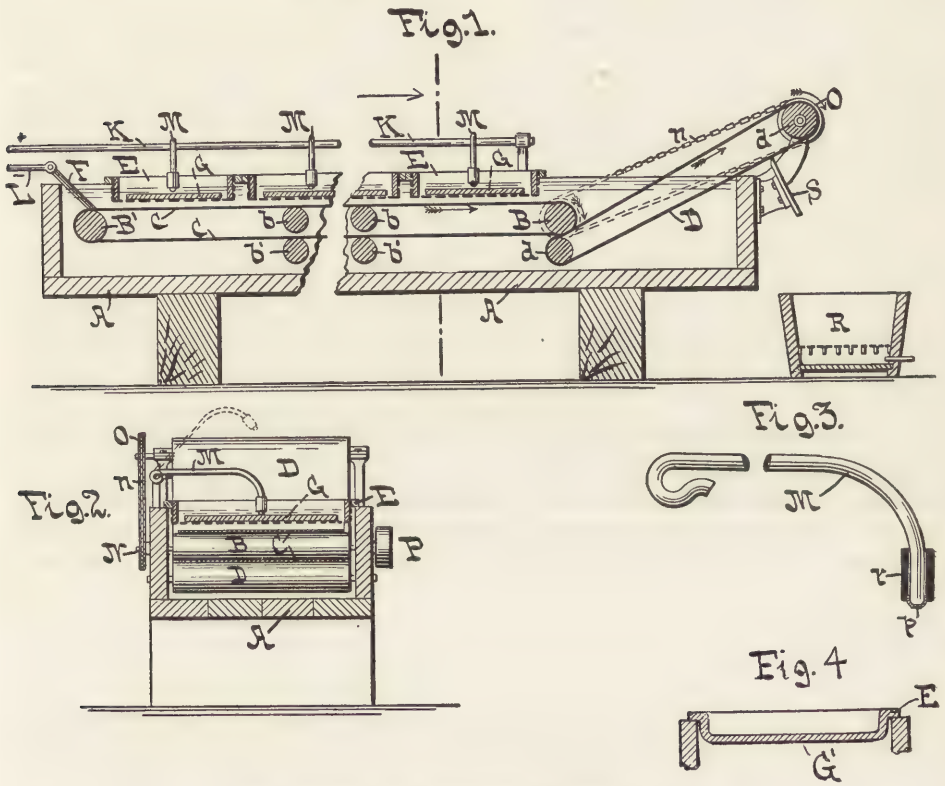
Electrolytic Separation of Copper and Nickel.—Matte or alloy, containing chiefly nickel and copper, is cast into anodes and dissolved by the electric current, while fine copper deposits on the cathode; nickel or nickel salts are obtained from the solution, now free from copper. Some Orford nickel copper matte or crude metal is treated by this method, it is said, at the Balbach Smelting Works, the nickel salts being crystallized from the electrolyte after the separation of the

copper, and shipped as nickel sulphate. Hering claims that it is not advantageous to electro-deposit the nickel, for such chemically pure nickel is not adapted, among other purposes, for making alloys, in nearly all of which the nickel must contain carbon.

ELECTROLYTIC TREATMENT OF SILVER SLIMES AND BULLION.

To the information contained in THE MINERAL INDUSTRY, Vol. II., pp. 278–282, we may add the following:

Moebius Process.—B. Moebius has improved his process for electro-refining silver bullion, and his latest patent (No. 532,209, of Jan. 8, 1895) places the cast bullion anode plates on the bottom of trays of porous earthenware or frames with



APPARATUS FOR REFINING SILVER BULLION.

muslin diaphragms, opposite the cathode. The silver is loosely deposited on an endless traveling band of sheet-silver or silver-faced rubber which forms the cathode, from which, on passing downward over a roll, the electrolytic silver is removed by scraping against an endless conveyor band. The latter lifts the silver out of the tank and empties it into a receiving-box. The electrolyte is a strong solution of sodium nitrate, acidified with sufficient nitric and sulphuric acid to keep some of the silver and all of the copper in solution. The above arrangement permits of a removal of the silver as soon as it is deposited, and prevents short circuiting caused by the formation of bridges between the anodes and

cathodes. As described in the patent specifications, the invention consists essentially in passing the cathode through the bath in close proximity to the anode or anodes, depositing the silver on the cathode in a loose, spongy or crystalline form, collecting the silver carried off by the cathode and discharging it continuously outside of the bath, and preventing the anions and cathions from being mixed with each other. The apparatus used by the inventor is shown in the annexed drawing, in which Fig. 1 is a sectional elevation of the apparatus, part being broken away. Fig. 2 is a vertical cross-section on the line *x—y*, Fig. 1. Fig. 3 is a detail view of the contact lever for the anodes. In these drawings *A* represents a tank of the usual construction for the electrolytic bath. *B*, *B'* are rolls placed within the tank, one of which, *B*, is rotated in the direction of the arrow by suitable means, such as the pulley *P*. *C* is an endless apron stretched between the rolls *B* and *B'* and supported by intermediate rolls *b*, *b'*. This endless apron is the cathode and is for this purpose formed entirely of sheet metal, by preference silver, or it may be made of sheet metal with a non-metallic backing; or of non-metallic material upon one side of which a coating of silver is deposited by electrolysis and firmly compressed during the process of deposition; or copper may first be deposited and then coated with silver. As seen in the drawing, the entire endless cathode is contained within the bath and is stretched horizontally. *E*, *E* are frames and *G* anode plates supported by said frames *E*. The bottom of the frames consists of diaphragms of muslin or other suitable material, such as porous earthenware, or the whole frame together with the bottom may be a dish of porous earthenware, as shown in Fig. 4, where *E' G'* is the porous dish. The frames *E* are supported upon the sides of the tank *A*, and can be removed. *D* is an endless apron or conveyor formed of rubber cloth, canvas, or other suitable material; it is stretched between rolls *d* and *d'*, the roll *d* being rotated in the direction of the arrow by suitable means, such as the chain *n* and wheels *N* and *O*. *K* is a conductor, supplied with positive current from the dynamo, and connected with the anodes *G* (formed of the bullion to be separated) by contact arms *M*. *L* is the conductor for the negative current, connected with the movable cathode *C* by brushes *F*. The contact arms *M* are by preference made of copper and the ends protected by rubber sleeves, *r*, and thin platinum caps, *m*, as shown in Fig. 3. *S* is a scraper bearing against the lower part of the apron *D*, and *R* a receptacle into which the silver or other deposit is discharged. The receptacle *R* is provided with a strainer for filtering off the liquid carried over with the deposit. The bullion to be separated is cast into anode plates *G*, which are placed in the frames *E* so as to be immersed in the exciting liquid, and the anions and cathions are thus separated by the diaphragms and prevented from mixing. As an exciting liquid the inventor uses by preference a strong solution of sodium or potassium nitrate sufficiently acidulated with nitric and sulphuric acid to keep some silver and all the copper in solution, such a bath being a very good conductor of electricity. When parting bullion containing silver, gold, copper, and other metals, a current of small electro-motive force is used, and the dissolved silver is precipitated upon the cathode *C* in a loose, spongy state, or in crystalline form; it is slowly carried by the cathode *C* over the roll *B*, and either collected in the tank near its end, whence it may be removed, or by preference collected upon a conveyor *D*, which

at once takes it out of the tank and discharges it into the receptacle *R*, whence it is taken to the melting pot. The copper is dissolved but remains in solution, provided the exciting liquid be properly acidulated and not too poor in silver and too rich in copper.

By slowly moving the cathode past the anodes, collecting the deposit therefrom and again presenting fresh surfaces of the cathode to the anodes, short circuiting, such as is generally caused by bridges formed between the anodes and cathodes, is prevented. The cathode may pass very close to the anodes, thus reducing resistance; the crystals deposited upon the cathode form part of the same, increase the surface and likewise reduce resistance. The work goes on continuously without interruption for cleaning; the silver is delivered ready for the melting pot, instead of being blocked up in the apparatus and requiring the investment of large capital. The apparatus is very simple and requires but little repair and attention.

The gold and the platinum metals are retained upon the diaphragms, together with lead peroxide, some peroxide of silver and other impurities. Whenever any one of the anode plates is exhausted, its contact lever is raised up and a fresh anode plate put in. The residue upon the diaphragms is collected in rotation, so that there is no interruption in the process. This residue, containing gold and other metals, is treated in the usual well-known manner.

The advantage claimed for the method and apparatus described is that the entire anode is subjected to the action of the current, and no scraps are left, which have to be remelted, as in other processes.

While the method and apparatus are designed particularly for separating alloys containing silver, they may be used for other purposes, such as the electrolytic deposition of copper in a loose, spongy state.

Electrolytic Silver Refining at St. Louis.—The following electrolytic method of refining was used at the works of the St. Louis Smelting and Refining Company, before they closed down, instead of the method of parting by sulphuric acid in the treatment of auriferous silver containing 0.005% of gold (28.8 grains per lb. troy). The silver is cast into plates measuring 10 by 8 by 2½ in., two of which are placed together in a linen bag to form one anode, with a rolled plate of fine silver for a cathode. The dissolving vessels are wooden vats, divided into seven cells, and rendered impermeable by a coating of bitumen, each vat containing 70 pairs of electrodes arranged in series. The electro-motive force required for each bath is 1½ volts, with a current strength of 350 ampères per sq. meter, which is furnished by a dynamo of 100 volts and 200 ampères driven by a 30 horse-power Westinghouse engine. The electrolyte used in the first instance is water containing one-tenth of one per cent. of nitric acid, which is made up with very weak solution of silver nitrate as the operation progresses. The anodes are entirely dissolved in from 30 to 40 hours; the reduced silver separates in a crystalline form, shooting across from the anode to the cathode, so that short circuiting very frequently occurs. To meet this difficulty an apparatus is used for scraping the deposit off the cathodes at intervals, which, at the same time, keeps up the circulation of the solution in the bath. The deposited silver so removed falls to the bottom of the bath into boxes with double bottoms, perforated and covered with linen, for collecting the precipitate, which is removed

once a day. The finely divided gold is kept back in the anode bags, where it is allowed to accumulate for a week before cleaning out. It is then boiled with nitric acid, washed, dried, and melted with a little sand or borax, giving a bullion 999 fine. The silver, after washing and drying, is found to be free from gold, and assays 999.5 fine. The silver nitrate obtained from the final treatment of the gold is used to keep up the bath to the proper strength. At St. Louis, 933 kilos silver (about 30,000 oz.) were parted by this method daily, and at Pittsburg a still larger plant of 40,000 oz. capacity is in use. At the latter place the finely divided gold is melted with a small quantity of silver before being subjected to the final boiling with nitric acid.* The electrolytic parting of the bullion does not run smoothly, it is claimed, unless the bullion contains at least 95% silver.

METHODS OF TESTING THE COPPER.

When the electro-deposited copper has formed sheets of sufficient thickness, these are lifted out of the tanks by means of overhead trolleys and tackle, washed from any adhering copper solution, and sent to the melting furnaces, there to be cast into wire-bars. From every charge of about 13 tons, two or three test bars, weighing 6 or 12 oz. each, are taken at the time of casting. These test bars are stamped with the date and the number of both charge and furnace, and together with a smooth and hard drawn wire, about $\frac{1}{16}$ in. in diameter and 12 ft. long drawn from one of the test bars, sent to the physical testing laboratory. There the purely mechanical properties of the copper, the tensile strength, elongation, and the number of twists the wire can stand are rapidly determined and noted, as well as the electrical resistance or conductivity. These operations are briefly described below. Only when these mechanical and electrical tests, which are rapidly and easily made, fall short of the required standard, a duplicate test bar is sent to the chemical laboratory, where the cause of the failure is then determined by analysis. The wire-bar charge is, of course, rejected, and the superintendent notified of the cause of the trouble in the refinery. The importance of an accurate investigation then becomes apparent.

Testing the Tensile Strength and Elongation.—A certain length of the uniformly thick and smooth wire to be tested, say 20 in., accurately measured off, is placed between the grip clutches of a Riehle machine for testing tensile strength, and the weight on the wire gradually increased until it breaks. The tensile strength can then be easily calculated in pounds per square inch, and the percentage of elongation can be determined by placing the broken pieces together and ascertaining the increase in length over 20 in. between the fixed marks on the wire.

Twisting Test.—Half a dozen pieces of the wire are cut off so that they are about 3 in. long between the ends, which are each about $\frac{1}{2}$ in. long and bent up at right angles. These pieces are placed one after the other in a simple twisting machine, and the number of the bends or complete rotations each will stand before breaking noted. The average number of twists of the six pieces is finally entered in the record book.

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* *Electrician*, July 20, 1894.

Testing the Electrical Conductivity.—The caliber of the wire, which must be smooth, is accurately determined at different points of the wire and averaged. The wire is then stretched by hand, and placed between the contact levers of a Walldorp machine, and its resistance compared with that of a standard wire of the same thickness and length. The resistance of the wires is measured in ohms and tenths of ohms by a delicate ohmmeter. The conductivity is thus easily calculated. As a check, a standard Wheatstone instrument and torsion galvanometer may be used from time to time, although this is seldom necessary in good work. Most electrolytic copper contains from 0.7% to 1.2% of cuprous oxide; other things being equal, the lower this percentage the greater the conductivity and vice versa. Annealing of the wire is said to raise the conductivity nearly 2%.

Influence of Impurities.—In order to determine the exact influence of various impurities on the electrical conductivity of copper, it is of great interest to secure analyses of the various kinds of electrolytic copper, together with their degree of conductivity. In the absence of recent data, the following analyses, which I made in 1893, are given:

	No. 1.	No. 2.	No. 3.
Cu_2O	0.5950 (=0.0666 oxygen).	0.6900	0.7400
Sb	0.0048	0.0110	0.0060
As	0.0016	0.0037	0.0005
Ag	0.0069 (=2 oz. Ag per ton).	undetermined.	0.0046 (1.3 oz. Ag per ton.
Bi		trace.	

Sample No. 1 was annealed Baltimore wire-bar copper, with a conductivity of 99%. Baltimore cathode copper contained only a trace of arsenic and antimony and casting copper 0.006% antimony.

Sample No. 2 was Anaconda copper of considerably lower electrical conductivity.

Sample No. 3 was a good conducting Anaconda wire-bar copper, obtained from a solution containing about 16% blue vitriol, 5% free sulphuric acid, and 29.6 mg. antimony, and 45.4 mg. arsenic to the liter, under ordinary conditions of Anaconda regime.

It has been noted that copper becomes brittle when 1 kilo contains only 1.5 grams of iron, and cannot be rolled if 0.1 gram antimony or bismuth be present. Six grams zinc in 1 kilo copper produces a red short alloy, just as 5 grams of arsenic, whereas 10 grams of arsenic makes the copper cold short. Dr. W. Hampe,* has drawn out copper containing 0.808% arsenic down to a thickness of 0.03 mm., and copper containing 0.529% antimony to an even smaller diameter. This shows that even relatively high percentages of arsenic and antimony have no injurious influence on the ductility of copper. The electrical conductivity of the following alloys (that of pure copper being taken as 100) was as follows:

I.	Cu. with 0.216% As	61	IV.	Cu. with 0.206% Sb	68
II.	0.351	50	V.	0.529% Sb	56
III.	0.808	30	VI.	0.526% Si	28

All three substances, arsenic, antimony, and silicon, increase the "ultimate strength" of copper, but reduce the electrical conductivity.

* *Chemiker Zeitung*, No. 42, 1892.

METHODS OF ANALYSIS.

Sampling.—Anode plates, cathode sheets and wire-bars (or sample bars taken during the casting of these) are sampled for chemical analysis by boring into them at several places with a machine drill and mixing the borings to obtain an average. Some shippers melt and granulate the borings, but this practice is neither necessary, nor does it give an accurate sample.

Electrolytic Determination of Copper.—Oettel* claims that the electro-deposition of copper, in the presence of much arsenic and small quantities of antimony, gives more accurate results when an alkaline (ammoniacal) solution, containing ammonium nitrate, is used than when the usual acid solution is employed.

Classen effects the separation of copper from nickel by adding ammonium oxalate to the mixed solution to form a double salt. The electrolysis is effected in heat, and the liquid kept acid by additions of oxalic, tartaric or dilute acetic acid. The tension at the electrodes must be kept within the limits of 1.1 to 1.3 volts.

Determination of the Impurities.—Electrolytic copper, while usually containing less silver and iron than Lake copper, often carries, beside the intentionally introduced oxygen, a little antimony, arsenic, and sometimes bismuth, selenium and tellurium. For determining these impurities Hampe's original method, consisting in taking out most of the copper by electrolysis and estimating the injurious elements in the remaining solution, although recommended for Lake copper, is not adapted to electrolytic copper. Fresenius' method, involving the precipitation of large quantities of copper with hydrogen sulphide, is exact, but too slow for the practical refiner. Better adapted and more rapid than either of the above methods, according to H. F. Keller, is Hampe's new method, in which the greater part of the copper is separated as sulphocyanate. This method is fully described by Keller in the *Journal of the Franklin Institute* of July, 1894, p. 54. For determining the arsenic, antimony and bismuth in electrolytic copper, as well as in refinery solutions, I have found Ray's method, as indicated in THE MINERAL INDUSTRY for 1893, pp. 276–277, and more fully described below, convenient and rapid.

Antimony and Bismuth Determination.—From 10 to 20 grams of the copper are dissolved in nitric acid, and sufficient iron (a little crystal of pure iron sulphate will do) added to convert all the arsenic and soluble antimony into iron salts. The solution is diluted, made ammoniacal, boiled, $\frac{3}{4}$ gram ammonium carbonate and a little sodium phosphate added, and the precipitate filtered. In the presence of both Am_2CO_3 and Na_3PO_4, the precipitation of the bismuth is guaranteed. The precipitate is dissolved in HCl, and this solution treated with H_2S; the sulphides are then leached with warm Am_2S or Na_2S and filtered. The residue on the filter, which may contain a little copper, is dissolved in nitric acid, and any bismuth present precipitated with ammonia and Am_2CO_3. If the copper is not completely separated, repeat the bismuth precipitation. The bismuth is dissolved on the filter and determined electrolytically in dilute solution. Any lead present does not interfere, as it is separated by the electrolysis. In the alkaline sulphide filtrate you determine the antimony by precipitation with HCl, dissolving

* *Chemiker Zeitung*, No. 47, 1894.

the antimony sulphide precipitate in a little warm concentrated HCl, leaving the arsenic sulphide undissolved, diluting, filtering, passing in H_2S, allowing to settle, decanting, transferring to a porcelain crucible, igniting and weighing as Sb_2O_4. If bismuth is not present the treatment with Am_2CO_3 and Na_3PO_4 is omitted.

Arsenic Determination.—The arsenic is determined in a second portion (10 to 20 grams) of the electrolytic copper. This is dissolved, as before, in HNO_3, iron salt added, then ammonia, boiled, and the precipitate obtained filtered off and dried. After powdering the same it is mixed with 6 to 8 parts of Na_2CO_3 and KNO_3 and fused, at first at a low heat and then strongly, until fusion is complete. It is then leached with water, and the insoluble residue filtered off. HNO_3 is added to the filtrate until the solution is acid; it is then boiled until all NO_2 and CO_2 have been driven off, cooled, neutralized with ammonia, and sufficient $AgNO_3$ added. The resulting Ag_3AsO_4 is filtered, dissolved in dilute HNO_3 (sp. gr. 1.2), and the combined Ag determined either by titration with AmCyS or by precipitating as AgCl and cupelling. From the weight of silver found we can easily calculate the arsenic present as 100 Ag=23.15 As.

Silver Determination.—One assay ton of the copper is dissolved in 75 c.c. HNO_3 and the excess of acid boiled off. When the fumes have disappeared, add water, heat, and precipitate with a slight excess of salt solution, after calculating the number of cubic centimeters of salt solution necessary to precipitate all of the silver. Allow it to settle over night, filter, wash, dry, burn filter to ash, and scorify with test lead, using borax glass or a little fine silica as cover. At the Parrot Works laboratory, the silver chloride on filter is covered with a little argol, which serves to reduce the silver and forms potassium chloride, and the filter is rolled up and placed on top of a scorifier containing test lead and a little borax glass and put in the muffle.

Oxygen Determination.—The method of determining oxygen by reduction of the oxidized copper with hydrogen is preferable to the less rapid and convenient nitrate method. The sample is obtained by filing a sufficient quantity of copper from the clean copper test bar with a perfectly clean velvet file, and freeing the filings from any dirt with pincers, and from any broken particles of iron with a magnet. About 5 grams of the sample are then placed in a weighed porcelain boat and kept as much as possible from the influence of the laboratory atmosphere. A number of oxygen determinations can conveniently be made simultaneously in the same glass or platinum ignition tube.

PRODUCTION OF ELECTROLYTIC COPPER IN THE UNITED STATES.

This has again largely increased and last year aggregated nearly 115,000,000 lbs. Not only have some of the old established refineries, such as those of the Balbach Smelting and Refining Company, the Baltimore Electrolytic Company, and the Bridgeport Copper Company, increased their output, but new works have been started or enlarged. Among these we have to mention the works of the Nichols Chemical Company, at New York; the Boston & Montana Company, at Great Falls, and the electrolytic works of the Anaconda Company, at Anaconda, which were remodeled on the Thofehrn plan during the past year, the works building at Salt Lake City, embracing a Bessemer and an electrolytic plant, and the large works of the Guggenheim Brothers, under construction near Perth Amboy, N. J.

Anaconda Refinery.—Since the publication of the article on the Anaconda Refinery in THE MINERAL INDUSTRY, Vol. II., pp. 274, 275, this copper refinery has been remodeled, and the multiple process, as modified by Thofehrn, has been substituted for the series process, until recently used at Anaconda and described in the article cited above. The series process proved too expensive and unreliable for regular obtainment of a good quality of "electro." According to Mr. Thofehrn, the Anaconda plant is now producing 50 tons of refined copper daily.

The refinery building covers 600 vats, containing anodes of cast blister copper and cathodes of thin sheet copper. Every anode furnishes two refined copper plates, each weighing about 100 lbs. Although it requires 20 days' time to dissolve the crude copper and transfer the refined copper to the cathode, so large is the refinery that 50 tons of the red metal are thus secured daily. The capacity for producing twice this amount of copper is only limited by the amount of power available. The electric current is generated in two great Westinghouse dynamos driven by two 500 horse-power engines, but these engines are soon to be supplemented by a 1000 horse-power Corliss engine, which is now being placed in position.

The current is conducted to the vats by means of copper tubes which surround the vats. By means of cranes a whole vat full of refined copper plates may easily be lifted out, or a new supply of anodes may be lowered into any of the vats. The action of the solution is barely perceptible, although it is constantly in motion. There are three departments or systems, each containing 200 vats. Two reservoirs in each section of the building supply the acid, which flows into the vats. The impure electrolyte, passing from the electrolytic vats, is thoroughly purified before it is pumped back into the reservoirs and used over again.

The slimes accumulating in the bottom of the vats are carried to the silver mill, and are there treated by the process described in THE MINERAL INDUSTRY, Vol. II., p. 281 (direct treatment with hot sulphuric acid and air), whereby the precious metals are eventually secured. The result of one clean-up has been a ton of silver bars assaying 999 fine.

By means of electrical meters, located in his private office, the superintendent can rapidly ascertain the exact condition of the electrolyte at any time, the quality of the deposited copper, and can also see if any one tank, and what particular tank, is not working properly. A defect can therefore be remedied immediately. Besides the meters and switchboards, there is in the office a miniature vat in which the copper refining process is in operation constantly, and from the copper therein produced assays are daily made. Electric cars convey the copper anodes from the copper dipping plant at the "Upper Works," to the refinery and transport the refined copper from the latter to the casting works.

Great Falls Refinery.—The electrolytic refinery of the Boston & Montana Company at Great Falls, which was originally planned for a capacity of 1,000,000 lbs. monthly, is now (February, 1895) producing at the rate of 1,800,000 lbs. monthly, equivalent to an output of 30 tons per day. This increase has been made possible by the increase in the capacity of the power plant. Three Thomson-Houston 180 K. W. multipolar machines and a fourth dynamo of 165 K. W. furnish the current, which is conducted 2000 ft. from the power-house to the electrolytic building. This building is of brick 110 by 174 ft. in size, and

has a double roof to obviate sweating during winter months, as the condensed moisture dropping on the electric connections interfered with the working of the electrolytic process. It contains about 288 lead-lined depositing vats, besides the necessary solution tanks. The multiple process of electro-deposition is employed. Two 125 horse-power boilers furnish steam for heating the building and boiling the solutions. In connection with the electrolytic plant are a blue vitriol establishment and a furnace refinery, the latter consisting of an iron building, 80 by 130 ft. containing three refining furnaces for melting down the electrolytic copper. An air compressing plant has been added to the electrolytic works for the purpose of forcing solutions to a higher level for circulation. It is understood that the refinery at Great Falls will eventually be enlarged to twice its present size, the required current to be generated at a very low cost from the abundant water power of Black Eagle Falls.

In regard to the sale of electrolytic copper it is to be noted that, while in 1893 the difference between Lake and electrolytic copper was usually $\frac{1}{4}$c. as against $\frac{1}{8}$c. in 1894, the large demand for wire-bars in 1894 enabled holders to realize full Lake prices at times, and in some instances even better prices for electrolytic than were obtainable for Lake.

COST OF ELECTROLYTIC WORKS AND REFINING.

After the selection of a system of refining, the next problem is to ascertain the net cost of building, equipping and running the necessary plant.

H. Fontaine * gives the following good method of calculating the net cost, and takes as an example refining works erected near Paris, possessing 120 tanks and producing annually 750 to 1000 tons of electrolytic copper by the improved multiple process. The total quantity of copper in treatment is then estimated as follows:

Anodes: Let us suppose each line of anodes is composed of two plates; we then have:

Length of plate	0.60 m.
Width of plate	0.60 m.
Maximum thickness	0.02 m.
Maximum weight of a plate	60 kg.
Weight of an anode	120 kg.
No. of anodes in a tank	13.
Total number of anodes in 120 tanks	1,560.
Total weight of anodes	187.2 tons.
Total surface of an anode	1.5 sq. m.
Total surface of anodes in tank	19.5 sq. m.

The total weight of the anodes, increased by the weight of the suspension lugs, approximates 190 tons. For the cathodes we have the following:

Length of sheet	0.60 m.
Width	0.20 m.
Thickness	0.0002 m.
Weight of sheet	1.84 grams.
No. of sheets forming cathode	6.
No. of cathodes in a tank	14.
Total number of sheets	10,080.
Total weight of cathodes	1,855 kg.
Active surface of sheet	0.216 sq. m.
Total surface of cathodes	2180 sq. m.

* *Electrolyse*, 1892, *p.* 288 *et seq.*

The attaching straps augment the weight of the cathodes about 10%, so that the cathodes represent about two tons of copper.

A current density of 50 ampères per sq. m. requires a current of 1090 ampères, but as it frequently happens that the cathodes are not made quite as large as the dimensions given, 1000 ampères will generally suffice. This current will deposit one kilo of pure copper hourly per tank, or 2880 kilos per 24 hours in the system of 120 tanks, equivalent, in round figures, to an average daily production of 2½ tons.

COST OF INSTALLATION OF WORKS.

Land 1500 sq. m., at 15f.		22,500
Principal building, 900 sq. m. at 30f.	27,000	
Superintendent's office and laboratory	20,000	
Chimney	4,000	
Various sundries	6,000	
		57,000
Engine and 45-horse-power boiler	30,000	
Tanks, timber frames	4,000	
Tanks, other woodwork	5,000	
Tanks, lead lining	10,000	
Dynamos and meters	12,000	
Conductors	12,000	
Anode casting furnaces	6,000	
Electric lighting	3,000	
Air compressors, pipes, filters	5,000	
Other original expenses	20,000	
		107,000
Total installation expenses or cost of plant		186,500f. ($37,300)

STOCKS AND SUPPLIES IN HAND.

Copper in the tanks—190 tons, at 1350f.	256,500	
Blister copper in stock—100 tons, at 1350f.	135,000	
Coal and other supplies	28,500	
Total	420,000f.	($84,000)
Cost of installation as above	186,500	
Total capital invested	606,500f.	($121,300)

ANNUAL WORKING EXPENSES.

Anode casting, coal	8,000	
Labor	2,000	
Maintenance	1,500	
		11,500
Making cathodes, at ½f. per kg		6,550
Tank work, labor		6,000
Power, coal, oil, maintenance		12,000
General expenses		10,000
Total		46,050f. ($9,210)

Summary.—The annual expenses for an average production of 900 tons are thus made up of the following items:

Working expenses		46,050f. ($9,210)
Interest on the price paid for the land	1,125	
Interest on the cost of installation	8,200	
Interest on the copper in the tanks	12,825	
Interest on the copper in stock	6,750	
Interest on various supplies	1,425	
		30,325f. ($6,065)
Depreciation of buildings, 5%	1,125	
Depreciation of machinery, etc., 10%	10,700	
		11,825f. ($2,365)
Total		88,200f. ($17,640)

The cost of producing a ton of electro-copper by the improved multiple process is therefore $\frac{88200}{900}$=98f. or $19.60.

This amount is made up of the following items:

Working Expenses.		
Anode casting	12.78	
Making cathodes	7.28	
Labor at tanks	6.67	
Power	13.34	
General expenses	11.11	
		51.18f
Interest on Capital and Stock, and Depreciation.		
Land interest, 5%	1.25	
Cost of installation	9.11	
Copper in the tanks	14.25	
Copper stocks	7.50	
General supplies	1.58	
Depreciation of machinery, buildings, etc	13.13	
		46.82
Total		98.00f. ($19.60)

In most of the copper refineries the silver slimes assay between 300 and 500 grams silver per ton of copper produced. At $20 per kilo this silver yields an income of $6 to $10 per ton, which sum considerably reduces the net cost of refining.

F. B. Badt * gives the approximate cost of an American refinery with a capacity of 500 tons of electrolytic copper per month as follows:

Building	$30,000
Pavement (asphalt)	2,000
Pipes for steam heating	4,000
Vats	6,000
Lead for lining vats, collecting tanks and troughs	28,000
Lead burning	1,500
Copper conductors	11,000
Rails for overhead blocks for handling plates	2,000
Sulphate of copper	3,500
Sulphuric acid	1,000
Steam injectors, or pumps, or air compressors	1,000
Electric generators, switchboard and instruments	30,000
Shafting and belting	3,000
Total	$123,000

To this sum must be added the copper under treatment, which will amount to at least $80,000; and if a steam plant is required another $20,000 must be added, so that $223,000 is the total cost of the plant. In the items in the table the cost of labor is included but not that of freights.

The cost of running a modern copper refinery per ton of refined copper was estimated by H. Thofehrn† as follows:

Treating Blister Copper of 95% to 98%.	
Manufacture of anodes	$2.50
Manufacture of cathodes	1.00
Manufacture of oxides	1.20
Labor at vats	1.50
Steam power	1.90
General expenses	.95
Interest and sinking fund, 70% of those for matte treatment ($4.35)	3.05
Total	$12.10

* *Engineering and Mining Journal*, Vol. LIV., p. 126. † The Mineral Industry, Vol. II., p. 283.

TREATING MATTES OF 50% to 60% COPPER.

Melting 2 tons at $1.75	$3.50
Oxidizing 2 tons at $2.20	4.40
Reducing to black copper and anode casting 1 ton	5.50
Manufacture of cathodes	1.00
Labor at vats	1.50
Steam power	3.50
General expenses	1.35
Interest and sinking fund :	
Interest on real estate	.38
Interest on investment in plant	.90
Interest on copper in treatment	1.05
Interest on copper in stock	.75
Interest on various supplies in stock	.15
Interest on sinking fund	1.12
Total	$25.10

In the *Engineering and Mining Journal* of July 30, 1892, the cost of treating a ton (2000 lbs.) of matte containing 50% fine copper, under favorable conditions, by Bessemerizing and electrolytic refining in the United States, was given at $12.50, or 1¼c. per lb. of fine copper. For treating copper mattes the principal refining works, nevertheless, charged from 1¾c. to 2½c. per lb., according to the quality of the copper produced, and allowed only 92½% on the commercial value of the silver separated. With the tolls at 2½c. per lb., the charge for treating a ton of matte assaying 50% copper was, therefore, $25. Competition among the electrolytic refining plants in 1893 crowded down charges until 1½c. per lb. of copper, allowing 95% of value of precious metal, was offered. In 1894 electrolytic copper refining in the United States cost on an average 1c. per lb. Now (January, 1895) it is stated on good authority, that the cost of refining 98% blister copper, at several of our large works, has actually been lowered to less than 0.5c. per lb., and that contracts can be closed for refining at 0.5c. The effect of a knowledge of this astonishing fact on the market will probably be to bring to American refineries much material that was formerly refined abroad. The causes of the great reduction in the cost of refining are the cheapening of labor and supplies, and the introduction of improved methods.

Some Recent Improvements in the Metallurgy of Copper.*

By E. D. Peters, Jr.

[This excellent review of the latest practice in copper metallurgy has been prepared by Dr. Peters from the advance sheets of the seventh edition of his great work on copper smelting, which is now in press. This work will cover, with great detail, the very latest and best practice in the principal copper works of the world, and will prove an extremely important contribution to copper metallurgy.—Editor Mineral Industry.]

Sampling.—Serious discrepancies occur frequently in shipping metallic pigs or anodes containing the precious metals. The plan practiced by large shippers is to bore each bar in one or more places, and melt and granulate the borings. Or they may be cast into a fresh bar, which is rebored for the sample.

Assaying.—The iodide assay for the determination of copper has practically become the standard method in England, having largely displaced the battery assay, as being equally accurate and more convenient. It depends upon the reaction that occurs when an excess of potassium iodide is added to a solution of a cupric salt in a slightly acid solution; cuprous iodide being formed, and an equivalent of iodine set free. This liberated iodine is held in solution by the potassium iodide, and is in exact proportion to the copper present. Thus:

$$2Cu\,SO_4+4KI=Cu_2\,I_2+2K_2\,SO_4+I_2.$$

The free iodine is determined in the usual way, by titrating with sodium hyposulphite, using starch as an indicator. Lowe of Denver finds the results of this method entirely satisfactory, but states that it is more convenient to first precipitate the copper in a metallic form by aluminum, and titrate the copper after dissolving it in very little nitric acid, and adding sodium acetate, acetic acid, and potassium iodide. This well known, though in America little practiced, method, with due care for details, is worthy the attention of all assayers.

The determination of gold and silver in rich copper ores or furnace material leads to frequent disagreements between miners, smelters, and refiners. Ledoux† calls for action on the part of those interested to settle upon some satisfactory and uniform system of determining these metals under such circumstances, as the various methods in use may give results that vary considerably.

In the East of the United States the combined wet and furnace method is generally employed for the determination of both gold and silver in copper furnace material. The Western assayers mostly use the straight furnace method, which agrees closely with the combined method as regards the silver, but generally gives a slightly greater yield in gold.

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* It is impossible for me to parcel out and acknowledge all the assistance I have received in preparing the material from which the following review is condensed. I desire to particularly thank Messrs. W. A. Clark, R. Sticht, C. M. Allen, H. Williams, H. A. Keller, C. W. Parsons, and H. C. Bellinger of Butte, Mont.; F. Klepetkow and G. M. Hyams of Great Falls; O. Stalmann of Salt Lake; N. P. Hill, R. Pearce, H. A. Vezin, W. L. Austin, M. W. Iles, and A. H. Low of Denver; A. S. Dwight and A. Raht of Pueblo; officials of the Anaconda Mining Company at Anaconda; James Douglas of New York; Titus Ulke of Washington; Fraser & Chalmers and H. F. Brown of Chicago; the directors and managers of most of the copper works in Europe and the United States; the directors of the Rio Tinto Company, Limited; also Messrs. Christopher James, T. D. Nicholl, and I. H. Clutton of Wales; M. Carnot of the *École des Mines*, Paris; Dr. Steinbeck of the Mansfeld Mining Company, and Professor T. Richter of Freiberg, Saxony.

† "A Uniform Method for the Assay of Copper Furnace Material for Silver and Gold," *Am. Inst. of Min. Eng.*, Oct., 1894.

Ledoux gives the following comparative results: High-grade copper bullion, containing about 400 oz. per ton in silver (1.37%), yielded in gold—

	By Fire Assay.	By Combination Assay.
Gold, oz. per ton	1.06 (0.00364%)	0.92 (0.00316%)
" " "	1.32 (0.00453%)	1.24 (0.00426%)
" " "	0.34 (0.00117%)	0.20 (0.00069%)

Three other lots of copper bullion, containing about 300 oz. per ton in silver (1.03%), yielded in gold—

	By Fire Assay.	By Combination Assay.
Gold, oz. per ton	4.06 (0.01395%)	3.96 (0.0136%)
" " "	2.76 (0.00948%)	2.56 (0.00879%)
" " "	2.72 (0.00934%)	2.44 (0.00838%)

Matte containing 60% of copper and 60 oz. per ton in silver (0.206%), yielded in gold—

	By Fire Assay.	By Combination Assay.
Gold, oz. per ton	0.24 (0.00082%)	0.20 (0.00069%)

CALCINATION.

The Heap-roasting of Pyritous Ores.—In THE MINERAL INDUSTRY, Vol. II., p. 261, I called attention to the excellent results obtained by the use of a minimum amount of wood in the heap-roasting of heavy pyritic ores, instancing especially the admirable work done in heap-roasting the richer, cupriferous pyrites at Rio Tinto, Spain. Since witnessing the practice there I have had opportunity to observe and test the results obtained by diminishing the fuel in the roasting of various qualities of pyrites, carrying 35% and more of sulphur. In every case the roasting has been decidedly improved, though the time has been lengthened from 10% to 40%. The actual money returns, however, are considerably in favor of the improved roasting: the more, as this quality of pyrites is generally low in value, and has been cheaply mined, so that comparatively little capital is tied up. The fuel should be used to merely kindle the ore at the circumference of the heap, and the further process of oxidation should be retarded to the greatest possible extent consistent with its thorough and steady advance. One cord (128 cu. ft.) of light wood is, in most cases, sufficient to kindle a heap containing 400 to 600 tons of ore.

Stall-roasting.—Pelaton's Roasting and Agglomeration Furnace presents some novel features, and is intended for the calcination of pyritic smalls, or other sulphides. It consists of a long, narrow, covered stall, provided with sheet-iron front, and cast-iron side doors. It contains a close-meshed grate running on rails to hold the ore. The charge of fine or granular ore, after being placed in the grate, is ignited from below. A light blast is used under the grate, and it is claimed that while the plant is cheap, the capacity is large, and that a 10-ton charge of most ores can be well roasted and slightly agglomerated in 12 hours. If such results could be constantly obtained in practice, the apparatus would be of much value in many places. Good results are reported from the Laurium galena mines in Greece, and from pyrites mines in Chili, that are working up their old piles of fines in this furnace.

Automatic Calcining Furnaces.—This is the era of automatic calciners. Until within two years the Brueckner Cylinder has been the most prominent automatic furnace for the roasting of pulverized copper ores and products. But

this machine, admirable in many respects, presents certain disadvantages where the cheap roasting of great quantities of material is desired. 1. The operation is not continuous. 2. A very small portion of the internal surface is active at any one time. 3. It makes much flue dust. 4. Fusible ores or mattes are likely to be rolled into hard, unroasted balls. 5. It is somewhat costly in proportion to its capacity.

Hearth Furnaces seem to offer greater advantages as regards capacity in proportion to first cost, and ease of management. They are particularly adapted to the roasting of leady mattes and other material that is inclined to sinter. They seem peculiarly suited to roasting pyritic gold ores and concentrates previous to their treatment by chlorination; nor can I see why they could not be changed into muffle furnaces, that, considering the space, labor, and plant saved, would roast pyrites for sulphuric acid manufacture more economically than any of the burners at present in use. The most prominent furnaces of this description now before the public are: The O'Harra Furnace, with certain modifications by Allen and by Brown; the Pearce Turret Furnace; the Improved Spence (Keller-Gaylord-Cole) Furnace; and the Brown Horseshoe Furnace. To these may be added two furnaces that are solely engaged in roasting zincblende ores, but that possess features of interest to the copper metallurgist, viz.: The Mathiessen & Hegeler Zinc Company's Furnace, working at La Salle, Ill., and Blake's revolving hearth calciner, at Shullsburg, Wis.

The O'Harra Furnace consisted originally of two long hearths, one above the other, through which plows were continually dragged by means of a chain which obtained its motion from grooved pulleys over which it ran. The chain and plows were, and still are, cooled by running for some distance outside of the furnace on their way from the lower to the upper hearth. The hearths contained a continuous, longitudinal groove, not for the chain to run in, as is stated by Schnabel and certain other writers, but for the protection of the chain in case of shut-downs, whose probable frequency and extent were evidently very apparent to the inventor. During such delays the tension was relaxed and the chain was supposed to subside into the groove. The hearths were heated by a sufficient number of external fireplaces along their sides. While the capacity of this furnace was large, and the roasting satisfactory, the repairs and delays were excessive. The chain and plows, riding on the hearth, constantly gave way and wore out. The plows tore up the hearth and dragged it to the front, and the life of a furnace scarcely reached eighteen months.

Allen effected a radical improvement by laying iron tracks through the hearths, and mounting the chain and plows on wheeled carriages. Brown's modification consisted in partitioning off little corridors on either side of the hearths, in which the tracks were laid, and through which carriages ran, supporting the chain, and especially the arm to which the plows were attached, one end of this arm being fastened to the carriage, while the other extremity projected through the partition wall of the corridor into the furnace. It is evident, therefore, that Brown had to use two chains, and two sets of rabbles, their arms nearly meeting at the center line of the hearth. It is also evident that there had to be a continuous slot in the partition wall to permit the travel of the rabble-arm. This modification has not been so entirely successful as its ingenuity would seem to

deserve. The main difficulty has been the tendency of the partition-tiles or castings to sag or loosen, and obstruct the continuous slot, through which the rabble-arm projects into the hearth. This trouble has been remedied by Brown, and independently by the Argo metallurgists, but a mere partial partitioning off of the hearth does not seem to be a sufficiently perfect means of protecting the tracks, carriage, and chain from the heat. Those who are running O'Harra furnaces claim that the chain, track, etc., might about as well be in the hearth proper, as it was before Brown's modification, and most of the O'Harra furnaces are run in this manner. Brown is entitled to great credit, however, for showing us the use of a continuous slot traversed by a rigid rabble-arm.

The Allen-O'Harra calciners at Butte have two hearths, each 9 by 90 ft., traversed by six plows, making a complete circuit in 3¾ minutes. They roast highly pyritic concentrates containing about 19% copper, 18% silica, and 40% sulphur, down to 8% or 9% sulphur. A considerable proportion of the concentrates are coarse, and all are wet. They lose 26% of their dry weight by calcination, thus, as is usual in calcination, making the operation advantageous in two directions, as it not only removes four-fifths of the sulphur, and enables a 55% matte to be made by a single fusion in reverberatory furnaces, but also diminishes by one-fourth the weight of the ore to be smelted.

The weakest point of even the improved O'Harra furnace is its repair bill. This is, to a considerable extent, unavoidable in a furnace where the track, carriages, and chain are all exposed to the flame and to the red-hot sulphides, and where their existence is entirely dependent upon the judgment and care of the fireman. But both Allen and Bellinger of Butte, and Fraser & Chalmers of Chicago, have introduced modifications that considerably lessen the cost of repairs. The wear on the carriage-wheel bearings is rendered unimportant by the employment of cheap renewable bushings. The chain has always been one of the most costly portions of the furnace, for though made of hand-welded steel links, it is apt to give way by opening at the welds. Chains have lately been made consisting of solid steel drop-forgings for the alternate links, these being connected by steel Ds, one long tongue of which is put through an eye and bent over, so that there is no weld in the entire chain. The consumption of fuel has been considerably reduced, with great benefit to the furnace and machinery, and without prejudice to the roast. The cost of erection has also been greatly diminished, while the furnace is stronger and more durable.

The Costs of Calcining in this furnace can be best studied at the Allen-O'Harras at Butte, Mont., as it is here that they are working on copper ores on the largest scale, and it is here that they were first adapted to the purpose. It is difficult to offer an estimate of costs that shall seem fair to both the partisans and the detractors of this furnace. The principal cause of this difficulty is the fact that the most important items of cost may be made to vary from 50% to 150%, according to the care and skill exercised by those in charge of the furnace. These items are the fuel and the repairs. It is very easy to fire in all three sets of fireplaces and burn 10 cords of wood per day; but equally good results are now obtained by firing in only one set, and burning but 3.2 cords of wood per day. Again, a very little carelessness in regulating the heat may damage the chain and running gear to the extent of $100 or more, in a very short time, and

augment the repairs to an excessive sum. But careful firemen can be found, and a month's observation of ten of these furnaces convinces me that there is no occasion for damaging irregularities or serious delays.

I think the following table of costs will be found about correct for the Allen-O'Harra furnace, when run with the regularity and skilled supervision that it receives at the works of the Montana Ore Purchasing Company, or the Butte & Boston Mining Company. The 9 by 90 ft. double-hearth calciners at these works average 50 tons each of concentrates in twenty-four hours. Much of this material is very coarse, some 8% of it coming from the roughing-jigs, and barely passing a 2-in. ring. The Butte pyrites decrepitates to a certain extent. The average of 150 partial analyses of certain of these concentrates is: Copper, 12.2%; iron, 31.9%; sulphur, 41.2%; silica 10.6%; silver, 0.012% (4.4 oz. per ton)—total, 95.912%.

The following table shows the cost of roasting these concentrates down to 8% sulphur, at the rate of 50 tons per day (100,000 lbs.) per furnace. In these works there are one foreman and one weighman per shift to eight furnaces. One fireman per shift attends two furnaces. One gallon of black oil at 14c. is used per 24 hours, for the machinery of the eight furnaces. No transportation of ore to or from calciners is included.

COST OF RUNNING ONE ALLEN-O'HARRA CALCINER 24 HOURS, TREATING 50 TONS.

	Total Expense.	Cost Per Ton.
Labor—¼ foreman at $4; 1 fireman at $4; ¼ weighman at $3—total	$5.75	$0.11.5
Fuel—3.2 cords wood (410 cu. ft.) at $4.70 per cord	15.04	0.30.1
Repairs	2.00	0.04.0
Lights, oil, and oiling	0.75	0.01.5
Two horse-power at $^.25 per day per horse-power	0.50	0.01.0
Interest on cost of furnace at 6% per annum	0.92	0.01.84
Total cost	$24.96	$0.49.94

The power required has been determined by indicator; the fuel, from the wood delivered to eight calciners during a month; the oil, lights, and proportion of labor in oiling, from the actual cost at the works. All these items, as well as the labor employed at the furnace, are easy to arrive at. Also, the first cost of a furnace, which can be checked in various ways. The only point open to dispute is the cost of repairs. This has been taken from a two years' run. The cost of repairs as given by H. C. Bellinger, superintendent Montana Ore Purchasing Company, Butte,* is only $1 per furnace per 24 hours. This figure was arrived at from new furnaces, only six months in operation, and which had not required many repairs or new chains. A chain costs about $130, and on heavy sulphides and constant running should, with due skill and attention, last about a year.

Cost of Construction.—The 9 by 90 ft. Allen-O'Harra furnace requires 125,000 red brick, 8000 firebrick, 36,000 lbs. cast iron, 30,000 lbs. wrought iron, and 52 perches stone work, more or less. Including excavation it costs in Butte about $6,000.

The Pearce Turret Furnace may be described as a long, narrow hearth, bent

* *Engineering and Mining Journal*, July 22, 1893.

around a circle, the circumference of which is a little greater than the length of the hearth, so that the two ends do not quite meet. At this broken part the roasted ore is discharged. The fresh ore is automatically fed from a hopper at the other side of the break, and is gradually stirred and moved forward by rabbles attached to hollow, air-cooled arms, revolving around a stationary central column. The wall of the hearth forming the inner circle is provided with a continuous slot for the sweeping passage of the two revolving arms, and this slot is closed by an endless steel tape, which revolves bodily with the rabble-arms, being continuously pressed against the slot, so as to mostly exclude the cold air. The entrance of outside air is still further counteracted by the employment of a slight blast under the grate and through the hollow rabble-arms, which balances the tendency of the draught to suck air into the furnace, cools all the exposed iron surfaces, and enables the metallurgist to introduce an accurately gauged quantity of air, for the purposes of combustion and oxidation. (900 cu. ft. per minute are used at Argo, when running on heavy pyrites ores.) The inner skewback wall, that is to say, the wall immediately above the slot, is hung from heavy I-beams, whose extremities are supported by the central column, and by the outer walls of the furnace. The bracing of the furnace is exceedingly simple and effective, consisting merely of circular iron bands for the outside, while the inward thrust is received by radial struts, like the spokes of a wheel, between the lintels and the central column. Two or three fireplaces are spaced around the outer circumference of the circle at appropriate points, the entering flame being kept from immediate contact with the ore by short curtain arches. The ore is stirred once in 40 seconds, or a total of 540 times during the six hours that it requires to pass from feed to discharge. Of course the time of roasting and number of stirrings can be regulated to suit the requirements of the material under treatment. The greater length of the outer circumference of the hearth, as compared with the inner, seems to have no ill effect on the result, the roasting being absolutely uniform over the entire width of the furnace, and the length of each individual plow-blade increasing slightly toward the outer circle, so that it can move the ore the slightly greater distance demanded by the increased size of the circle. These plows are simply plates of ¼-in. steel, and last four to six weeks on pyrites containing 40% sulphur. The rabble-arms that carry the plows are of 5-in. pipe, and last a year. When the plows require renewal, the entire rabble-arm is uncoupled outside of the slot, and withdrawn through a door in the outer wall, a fresh one with plows already in position being at once substituted. The width of the hearth in the original furnaces is 6 ft., but some are now being built 7 ft. wide. The diameter of the enclosed circular space is 19½ ft., and of the furnace over all, 36 ft. The fireplace projects 6 ft. further, and the entire furnace can stand in a quadrangle 36 by 42 ft., thus occupying 1512 sq. ft. About two horse-power is required to run the furnace and blast. Apart from repairs and renewals, which are slight, no labor is required at the furnace, except to oil the machinery, to fire, and to have a general supervision of its behavior.

Some of the results obtained in ordinary work by this furnace are as follows: Of iron pyrites containing 43% sulphur and crushed to pass a two-mesh screen (9 mm. openings), 16 tons per 24 hours are roasted to 6% or 7% sulphur, using

2¾ tons of Colorado slack coal. Of matte from the lead smelters, containing 11% lead, 15% copper, and 17% sulphur, crushed through a six-mesh screen (3 mm. openings), 11 tons are roasted in 24 hours to 3.3% sulphur. Of concentrated stamp-mill tailings (pyrites), with 45% sulphur and 10% silica, 9 tons were dead-roasted in 24 hours, to show the utility of the furnace for roasting for the extraction of gold by chlorination. No trace of sulphur remained in the roast.

Of Butte concentrates from the Gagnon mine, consisting of variable mixtures of pyrites and blende, but always high in zinc and sulphur, 15 tons per 24 hours are roasted to 6% or 7% sulphur. The following analysis represents an average sample of these concentrates: Silica, 18.2%; iron, 20.3%; zinc, 14.85%; copper, 11.29%; sulphur, 31.53%—total, 96.17%.

The Colorado Smelting and Mining Company of Butte has erected a double-decked turret furnace, the upper hearth of which is supported upon an arch that takes its peripheral bearing upon the main external wall of the furnace, while its inner skewback is supported by the same interior wall that has been already described as hanging from the heavy radial 12-in. I-beams; the inner wall above the slot of the upper hearth being, in its turn, hung from a second set of I-beams, six feet higher than the set belonging to the lower hearth. This double furnace has been only a short time in operation, but excellent results are reported therefrom, especially as regards the consumption of fuel. Each hearth is provided with two fireplaces, and Mr. H. Williams, the manager, reports that, while the capacity for ore is increased, as might have been expected, 80% or 100%, the consumption of fuel is only heightened about 33%. This is an extraordinary, and to me unaccountable, saving in fuel, which I can only explain by assuming that much heat is wasted in the single-hearth furnace; probably because a somewhat high heat is used just before the end of the operation to partially decompose the sulphates remaining in the roast, and much of it must be lost, owing to the short distance between the third fireplace and the stack.

Indeed, as since the introduction of satisfactory automatic calcining furnaces fuel has become the main expense in the operation of roasting, it seems a mistake that no more is attempted in the utilization of the heat generated by the oxidation of the pyrites. When we reflect that the heat thus produced is ample to smelt the sulphides themselves as well as an equal weight of dry ores, and that it is thus utilized in pyritic smelting, we cannot fail to be struck by the seeming extravagance of employing large quantities of expensive carbonaceous fuel to burn up nature's own fuel in the ore. The actual quantity of heat generated by the oxidation of sulphides is exactly the same, whether this oxidation be effected in the pyritic smelting furnace or in the calciner. But in the smelting furnace it must be oxidized rapidly in order to generate the intense heat necessary for fusion, while in the calciner the oxidation is slow and quiet, being spread over several hours, so as to produce only the moderate temperature suitable to the process. Most of this heat escapes through the stack, and in heating the air that is admitted or finds its way into calcining furnaces. The two most obvious means of utilizing this slowly generated heat are:

1. By building the hearths in such close juxtaposition that the enormous loss by radiation is lessened, and the waste heat is stored up in the great masses of brick-work forming the furnace. Examples: The improved Spence at the Parrot

smelter at Butte, and Steinbeck's multiple-hearth, circular automatic calciner at Mansfeld, the latter of which runs regularly on argentiferous white metal for the Ziervogel process, absolutely without fuel. The Parrot furnace also runs for days on heavy sulphide ores, at the rate of 30 tons per day or more, with cold fireplaces; and when fuel is used, it is simply to increase the capacity of the furnace. This type of furnace must not be confounded with furnaces that have their hearths built one above another in what appears to be the same fashion, but where the constructors have taken elaborate measures to carefully isolate and cool each individual hearth. In order to save the possible racking and distortion of the furnace, they sacrifice the main advantage of this method of construction: *i. e.*, the conservation of the heat.

2. By employing the waste heat of calcination to preheat all air that is to enter either the hearth or the ash-pit. Pearce pursues this plan, to a certain extent, in his turret furnace, much of the air entering the hearth being preheated by its passage through the rabble-arms, or by passing through canals in the walls of the furnace. Blake carries this still further in his revolving-hearth Cornish calciner at Shullsburg, Wis., preheating the air with the aid of extraneous carbonaceous fuel. He claims valuable results from this system, though it seems a pity to waste coal on preheating the air, when such a vast store of heat is available from the operation itself.

Of all the mistaken ideas in the construction of calciners, that of cooling the hearths, except for the purpose of preheating the air used for this purpose, seems to me the most illogical. The occasional disadvantages of distortion can be better borne than the constant waste of fuel. It is like cooling the hearth of a reverberatory smelter by a water-jacket, or by the active circulation of air under a *thin* hearth, and then wondering why the charges take so long to bring, or why they stick so persistently to the bottom. As it is now the fashion to invent automatic calciners, and as the main opportunity in improvement lies in the lessening of the fuel-consumption, it would be most profitable for all aspirants in this direction to spend a week in working at a battery of the pyrites-burners, or kilns, as used in the great sulphuric acid works. They would at least learn that the glowing brick-work of the burners is the one kindler, regulator, safety-valve, and balance-wheel of the whole operation. The tendency at present is to drive calcining furnaces rapidly, and burn the sulphur and iron at the highest allowable temperature by means of the heat derived from extraneous fuel, in order to obtain the greatest possible output from a limited calcining capacity.

Investment in plant, within reasonable limits, is cheaper than coal at $3 to $6 per ton, and it seems probable that slower running, a lower heat at the commencement and through the greater part of the calcining process, and a greater area of hearth per ton of material roasted, will admit of a more thorough utilization of the heat evolved in the combustion of the ore, and a marked saving in carbonaceous fuel.

Both at Denver and Pueblo, and as well in the O'Harra as in the Pearce calciners, the residues from the distillation of the Florence petroleum are used for firing, to a certain extent, and are found a most convenient and manageable fuel for the purpose.

The Costs of Calcining in the Turret Furnace have been looked into and dis-

cussed by many of our copper men, as these furnaces are in regular operation at three of the greatest smelting centers in the country: Denver, Pueblo, and Butte. But Mr. Pearce has kindly furnished me with some exact figures from the Argo records that are of value to the profession. Three turret furnaces were run on a certain pyritic ore from Dec. 2, 1893, to Jan. 20, 1894. In this period of 48 days there were calcined 2319.558 tons of ore, being a trifle more than 16.1 tons per furnace per day. The ore contained about 25% silica and 75% sulphides, mostly pyrite. Its sulphur contents averaged 36%. It was roasted down to about 4.75% sulphur at the following cost, the transportation to and from the furnace being omitted, as it is a variable item at different smelters, and has nothing to do with the cost of calcining:

TABLE OF COSTS FOR THREE FURNACES RUNNING 48 DAYS.

		Total Expense.	Cost Per Ton.
Labor—1 man per 12-hour shift at $2.25, and extra labor		$225.60	$0.09.73
Coal—235.47 tons at $2.15	$506.26		
132.47 tons at $1.55	205.32		
367.94 tons unloading at 8c	29.43		
		741.01	0.31.95
Repairs—New rabbles and sundries		16.00	0.00.69
Power, steam, and oil		180.00	0.07.76
Interest on furnaces at 6% per annum		128.10	0.05.52
Total cost		$1,290.71	$0.55.65

The following table gives the cost of calcining pyritic and zincy concentrates from the Gagnon mine at Butte in the turret furnaces at Argo. A partial analysis of these concentrates is given on a preceding page. They contained 14.85% zinc and 31.53% sulphur, and were roasted down to 7.44% sulphur, at the rate of 16.889 tons per day; 1.02% of the residual sulphur was present as zinc sulphate; 152.093 tons were calcined in 9 days.

TABLE OF COSTS FOR ONE FURNACE RUNNING 9 DAYS.

		Total Expense.	Cost Per Ton.
Labor, as before		$14.12	$0.09.28
Coal—17.945 tons at $2.15	$38.58		
9.595 tons at $2.00	19.19		
27.54 tons unloading at 8c	2.20		
		59.97	0.39.43
Repairs—New rabbles		4.00	0.02.63
Power, steam, and oil		9.00	0.05.91
Interest on furnace at 6% per annum		8.01	0.05.26
Total cost		$95.10	$0.62.51

At Butte, Mont., with wages at $3.50 per day, and slack coal at $3.50 per ton, the cost of roasting the above concentrates in the turret furnace is about 68c. per ton.

Heavy Leadville pyrites, containing iron 41%, sulphur 46%, silica 5%—total, 98%—is roasted down to 4.46% sulphur, at the rate of 14.768 tons per day, at a cost of about 57c. per ton.

Concentration-matte from the lead smelters, containing copper 34.4%, iron 18.3%, sulphur 21.3%, lead 11.8%—total, 85.8%—was roasted down to 6.89% sul-

phur, at the rate of 13.019 tons per day per furnace. In 8 days 104.154 tons of this matte were roasted, with the following costs:

TABLE OF COSTS FOR ONE FURNACE RUNNING 8 DAYS.

	Total Expense.	Cost Per Ton.
Labor, as before	$12.54	$0.12.04
Coal—26.6 tons	53.49	0.51.35
Repairs—New rabbles	4.00	0.03.84
Power, steam, and oil	8.00	0.07.68
Interest on furnace at 6% per annum	7.12	0.06.83
Total cost	$85.15	$0.81.74

The turret furnace would seem peculiarly adapted to the calcination of auriferous pyrites for extraction by chlorination. Indeed, several are now constructing for that purpose.

In a trial run at Argo, concentrated tailings from the stamp-mills of Gilpin County, Colorado, containing about 79.5% pyrite (representing 42.1% sulphur), were roasted down to 0.22% sulphur, at the rate of 9.813 tons per furnace per day. In 8½ days 83.411 tons were calcined, with the following costs:

TABLE OF COSTS FOR ONE FURNACE RUNNING 8½ DAYS.

		Total Expense.	Cost Per Ton.
Labor, as before		$23.69	$0.28.4
Coal—11.64 tons at $2.30	$26.77		
7.981 tons at $1.75	13 96		
19.621 tons unloading at 8c	1.56		
		42.29	0.50.7
Repairs—New rabbles, etc		6.20	0.07.43
Power, steam, and oil		7.42	0.08.90
Interest on furnace at 6% per annum		7.56	0.09.07
Total cost		$87.16	$1.04.5

Flue Dust.—As may be inferred from the quiet and regular mechanical movements that occur in the turret furnace, its production of flue dust is very small. In cleaning up the dust chambers and flues after a run of 2726.542 tons of ore, 22.65 tons of dust were recovered, being 0.8%.

The Cost of a turret furnace at Argo, as built by the inventor, Mr. Pearce, is $5460.70, inclusive of royalties.

I am indebted to the kindness of Mr. A. S. Dwight, superintendent, for the cost of the two new turret furnaces erected at the Colorado Smelting Company's Works at Pueblo. The total expense, including royalties, was $12,296, or $6148 each. In this case there were some extra expenses, owing to necessarily extensive foundations, firebrick hearth, arches, etc.

The Turret Furnace is a model calciner in its running, and in the manner in which its mechanical details have been worked out. It is entirely automatic in its action, one man attending three or more furnaces. It requires less than two horse-power to run, and its repair-bill is mainly confined to changing plow-blades once in four to six weeks, and in renewing rabble-arms annually. In only one respect does it seem to me open to criticism, and that is in its consumption of fuel. This is, on good pyritic ores, some 16% to 18% of the weight of the ore; and though it must be remembered that Argo conditions demand a considerably

more thorough calcination than is required at Butte, and that it takes more fuel to reduce the sulphur in an ore from 10% down to 5%, than to lower it from 40% to 25%, yet there is, nevertheless, too great a loss of heat, and too little use made of the caloric generated by the oxidation of the sulphur and iron in the furnace. That this is the principal direction in which we must look for a still greater reduction in the cost of calcination is evident when we note that the fuel, even at the comparatively low price of coal in Colorado, forms about 60% of the total cost of roasting pyritic ores down to from 4% to 7% sulphur.

The Improved Spence Calcining Furnace was designed and erected for the Parrot Silver and Copper Company, by Messrs. Keller, Gaylord & Cole. The company has lately added two new ones, and now has three of then running at its smelter at Butte, Mont., which have displaced the twelve long reverberatory calciners there in use, as well as the ordinary Spence furnaces which were erected at the Parrot some three years ago. The improved Spence was originally designed as a circular furnace, though the stirring arms returned idle on their track, without ever completing the entire revolution, as in the other circular calciners. But the inventors eventually settled on the present rectangular form, and the furnace is now built as two sets of five hearths (and a drying-hearth), the driving mechanism being between these two blocks, and the whole thing constituting a single furnace. There are, of course, six sets of rabble-arms on each side, one set above the other, projecting through slots into their respective hearths. The rabble-arms are provided with plows both above and below, as in the O'Harra furnace, and these plows are only in contact with the ore when traveling in one direction. When their motion is reversed, a tripping mechanism turns the arm one-fourth of a revolution, so that both its sets of plow-blades lie horizontally above the ore, and in this position the rabbles move back to the other end of the furnace. When they reach this point the arm is again tripped and again revolves 90°. But the revolution of the arm always continues in the same direction, so that the plows, that were at first projecting perpendicularly into the air, are now brought into use. By this ingenious device, the plows are enabled to cool off, and the two sets of plow-blades are so fitted on the rabble that they constantly alternate in the ridges and furrows of the ore on the hearth. The driving gear consists of a wire rope, the extremities of which are attached to the rabble-frames, while the ropes themselves pass around a large driving wheel, on whose shaft is keyed a pinion that receives reciprocal motion from a rack actuated by a hydraulic piston. The slots are closed by traveling steel tapes, as in the turret calciner; but this furnace being longitudinal, and the motion of the rabbles being reciprocally to and fro, the tapes are wound and unwound alternately on horizontal pulleys placed at each end of the hearth. These are governed by springs so as to keep the tape taut, and its winding is assisted by counter weights. The hearths are three feet apart vertically, and are covered with silicious tailings from the concentrator. The enormous mass of brickwork contained in the superincumbent hearths and arches retains much of the heat generated by the oxidation of the sulphides, and consequently diminishes the fuel consumption to a point that would seem impossible to those who have not given attention to this particular subject. There is a 2½ by 4 ft. fireplace fired with refuse slack coal to each block of hearths; that is to say, two fireplaces to

the double block forming a single furnace. The flame is only allowed to traverse the top hearth, where it is used to ignite the sulphur quickly, the temperature on the lower hearths being ample, without extraneous heat, to reduce the sulphur to the required standard, 7% to 10%. I am informed that by using more time and fuel, there has been no difficulty experienced in reducing the sulphur to any desired limit.

The following results are taken mainly from written statements made to me by H. A. Keller, superintendent of the Parrot smelter, and one of the inventors of the furnace, and therefore cannot carry the same weight as though made by unprejudiced observers. But it is only just to say that personal observation and careful questioning of the workmen employed about the smelter, especially in regard to repairs, stoppages, and fuel consumption, have failed to detect any exaggeration in the claims made. The furnace has been mainly run on mixed sizes of concentrates from the Parrot mine, of which the following was the average composition for the first nine months of 1894: Copper, 9.8%; iron, 33.8%; silica, 13.3%; sulphur, 41.2%; silver, 0.027% (8 oz. per ton)—total, 98.127%. Mr. Keller states that while roasting 45 tons (90,000 lbs.) per 24 hours of the above concentrates, the furnace has, during the past three months, burned three-fourths of a ton of inferior slack coal, at $3.50 per ton. The coal averages about 18% ash.

The ore is fed to the calciner automatically by heavy fluted rollers; and as the bringing of the raw ore to the furnace, and the removal of the calcined ore, depend for their cost upon the general arrangement of the plant, and are, therefore, so variable at different works as to completely invalidate any exact inquiry into the comparative cost of roasting in different types of calciners, I have entirely omitted them in every case, preferring to let each smelter calculate the cost of above items to suit his individual conditions.

Since the reverberatory calciners have been given up at the Parrot smelter, there is no roasting foreman. The three improved Spence calciners are attended by one man per 12-hour shift, who fires (handling ⅜ ton of coal for each furnace), and, beyond this, simply has to oil and oversee the machinery. As his wages are $4 per shift, and the amount of ore handled per shift by the three calciners is 67½ tons, the cost of labor per ton is not quite 6c. Using ⅜ ton coal per shift, at $3.50 per ton, and roasting 22½ tons of ore, the cost for fuel per ton of ore is 5.83c. The furnace has been run for several successive days without any fuel at all, the duty being reduced from 45 to 30 tons ore per 24 hours. It is stated to require two horse-power to run the furnace. I find from personal inquiry that most of the Butte metallurgists who have carefully followed the development and operation of this furnace seem inclined to admit the correctness of the above statements so far as regards labor and fuel consumption, but are not in a position to express a positive opinion as to the repairs. I examined the record of the furnace on the Parrot books and found that its stoppages were about 12 hours per month, mainly for renewing rabble-arms and attending to the steel tape that closes the slots.

Mr. Keller's own statements (Dec. 2, 1894), regarding the total repairs on one furnace for the past 12 months, are as follows:

Thirty-six sets of plow-blades at $8.94	$321.84
One full set of 4-in. pipes for arms (12 pipes, each 7 ft. long)	29.40
Other repairs, averaging $5 per month	60.00
Total	$411.24

being about $1.13 per day. Mr. Keller calls the repairs $1.25 per day, or 2.78c. per ton of ore. The rake-end is the only portion of the rabble-arm exposed to heat, and its life, when running 45 tons of ore per day, is four months, more or less, according to whether it belongs to one of the hotter, or one of the cooler hearths. As they form the main item of repairs, it is interesting to know their cost in detail:

COST OF ONE RAKE-END.

Seven feet 4-in. pipe at 35c	$2.45
Eighteen cast-iron plow-blades, 7 lbs. each, at 4c	5.04
Nineteen 6-in. bolts at 10c	1.90
One-half day machine work at $4	2.00
Total	$11.39

It is claimed by the inventors that there is no racking of the furnace, nor distortion of slot. There are no firebrick used in the furnace, except where red brick are so fusible as to be unfit for lining the fire-box.

It will be interesting to assemble the figures already given, and thus determine the cost of roasting at the Parrot smelter, as claimed by Mr. Keller and his associates.

The cost of erecting one of these 45-ton improved Spence furnaces at Butte is about $10,000. The interest on the above sum, at 6% per annum, would amount to 3.6c. per ton of ore.

COST OF ROASTING ONE SHORT TON OF ORE IN IMPROVED SPENCE CALCINER.

These figures are deduced from H. A. Keller's statements, based on 12 months' running. Transportation of ore to and from furnace is not included.

Labor, per ton of ore	$0.06.00
Fuel, per ton of ore	0.05.83
Repairs, per ton of ore	0.02.78
Power and oil, per ton of ore	0.02.22
Interest on cost of furnace, per ton of ore	0.03.6
Total	$0.20.43

or about 20½c. per ton of raw ore.

While these unusually low figures are based primarily on Mr. Keller's own figures at the Parrot smelter, I should not give them here did I not believe them to be in the main correct. But a personal examination of the furnace, and a recent visit to the Mansfeld works in Germany, where approximately identical results have been obtained for several successive years in Dr. Steinbeck's modified Parkes calciners (calcining white metal, without fuel, for the Ziervogel silver extraction), has enabled me to assimilate these results with less astonishment than many metallurgists will probably experience. The main doubtful point with me is the question of repairs, and on this point I have not had a sufficiently long acquaintance with the furnace to express an intelligent opinion.

The Brueckner Cylinder is too well known to require mention in this connection, but I append a table of costs for the benefit of those who may wish to institute comparisons. These results were obtained at the works of the Anaconda Mining Company of Montana, where 156 of the cylinders, 8 by 18 ft., are in operation. They comprise the work of four weeks (28 days). The ore calcined con-

sisted mainly of concentrates containing 38.4% sulphur and 16% silica, and was roasted down to 8.1% sulphur. In 28 days a cylinder treated 341 tons of dry ore, or 12.186 tons per day. It used 2.95 cords wood (378 cu. ft.) per day, costing $10.26, or 84½c. per ton of ore. This wood could be unprofitably replaced by 2.63 tons inferior coal, with 20% ash, or by 1.625 tons of better coal, with 10% ash. One laborer, at $3 per shift of 12 hours, attended three furnaces, costing $2 per day per furnace, or 16.4c. per ton of ore. This makes $1.01 per day, to which must be added the expense of power, repairs (small), recrushing and recalcining lumps and rehandling flue dust (large), oil, lights, foreman, and interest on plant ($6,000). This brings the total cost to about $1.40 per ton of ore.

The cost of roasting similar material, under similar costs and conditions, in the ordinary long hand-calciner will not vary far from $1.80 per ton.

The Brown Horseshoe Furnace is also annular, like the turret furnace. But it is bent around a larger circle, the diameter of the unoccupied space in the center being 41 ft. 10 in., and the outer diameter 68 ft. 2 in. With its external fireplaces it occupies a quadrangle of 73 by 68 ft., or an area of 4964 sq. ft. The hearth proper is 8 ft. wide in the clear, and occupies about four-fifths of the circle, the remaining fifth being completely cut out, the free space thus formed being used to cool the rabbles. By means of projecting tiles in roof and floor, a narrow gallery is formed on either side of the hearth. The gallery on the outer circumference contains simply a rail of hard-baked tile, on which runs the outer wheel of the stirring-carriage. The inner gallery contains an iron rail for the inner wheel of the same carriage, and also the horizontal grooved idler-pulleys which guide the driving-cable. This cable is driven by a simplified adaptation of the means employed on cable-roads, consisting of a grip-wheel, with tightener and guide-sheaves. The cable, guide-sheaves, and inner rail are cooled by admitting a little air around each sheave into the inner gallery, and it is undoubtedly a valid claim of the inventor that when the furnace is properly run none of this ironwork becomes hot enough to seriously scorch the naked hand.

The ore is charged from an automatic hopper and apron, and, as in all similar calciners, is gradually carried around to the other, or discharge-end, by means of plows, which are attached to carriages running on the two rails already described. These carriages and their attached plows are intermittently cooled in a very peculiar and original manner. There is always one carriage standing idle on the rails where they cross the open space between the adjacent ends of the hearth. It requires about two minutes for each stirrer to make the circuit of the hearth, so that the idle one has this same length of time to cool off in. After its emergence from the hearth, the moving (heated) carriage comes in contact with the cooled one that is at rest, pushing it forward a short distance, until the carriage in the lead becomes attached to the driving-cable by means of an automatic grip, the heated carriage being detached at the same moment. The Collinsville Zinc Company of Illinois, and the Glendale Zinc Company of South St. Louis, Mo., after steadily running the furnace for several months, report that the action of the grip, cable, and sheaves is satisfactory, in spite of the high temperature used in roasting zincblende.

It is stated that one and one-half horse-power is required to run the machinery.

Also, that in roasting heavy zincblende ores, about 20,000 lbs. of finished product is made per 24 hours, the ore averaging over 30% sulphur, and being roasted down to 0.85% or 1%. There are four fire-boxes on the Collinsville furnaces, and about 12,000 lbs. of refuse slack from the adjacent coal mines is used per 24 hours. Of course this is no fair test as to what the furnace would accomplish on ordinary pyritic ores, but there seems no reason to doubt that the furnace will oxidize as rapidly and effectively as any of its rivals under equal conditions.

The Consolidated Kansas City Smelting and Refining Company has just erected one of these furnaces for the sulphate-oxide calcination of its copper-lead mattes for the Hunt & Douglas copper-extraction process. The results are reported to be satisfactory, but I have not yet received the details. The furnace has stood a severe test in its satisfactory work on zincblende ores for more than a year, and has now entered into competition with the other automatic copper calciners.

Brown urges, as a valuable feature of his furnace, the long road that each particle of ore has to travel. He claims that it is thus peculiarly suited to the roasting of easily fusible ores, as they are advanced so slowly and gradually toward the hotter portion, that the sulphides have ample time to decompose, and lose their extreme fusibility before being subjected to a temperature higher than they can bear.

The Mathiessen & Hegeler Zinc Company of La Salle, Ill., has developed since 1889 a peculiar, but, for zinc ores, effective type of calciner furnace. In estimating its work, it must be remembered that it is used solely for the sweet-roasting of zincblende ores, and that its gases are employed for the manufacture of sulphuric acid, when it is so desired. It consists of two seven-storied hearths, built side by side in one block, the hearths being 4½ by 46 ft., and possessing a common division wall. The furnace is heated by generator gas, the flame passing back and forth under the three lower hearths, the upper ones receiving no extraneous heat. There is one rake for each double hearth, and this implement rests most of the time on a swinging platform at the end of the hearth. About once an hour the rake is attached by hand to an iron bar that is pushed through the hearth from the opposite end, and is then dragged back through the ore, the bar being moved by friction-pulleys. The outside platform, on which the rake normally rests, can be swung around opposite the opening of the twin hearth, and is then dragged back through the latter in the same manner, being thus exposed but a short time to the high temperature of the hearth. The company informs me that a double seven-story furnace produces 40,000 lbs. of thoroughly roasted ore per 24 hours from 47,000 lbs. of zincblende, with a consumption of 9600 lbs. of refuse slack coal.

*Blake** describes a tabular revolving roaster, with automatic feed and delivery, that is said to be an improvement on Brunton's Cornish calcining furnace. It is intended and used for calcining the iron pyrites in the impure zincblende of Shullsburg, Wis., so that it may be easily removed from the blende by mechanical concentration. It could, of course, be adapted for copper ores. It consists of a circular terraced table, 16 ft. in diameter, covered with firebrick, and made to revolve slowly (10 revolutions per hour) in a horizontal plane. It is supported upon cast-iron balls running in a grooved circular track, 12 ft. in diameter, and

* *Trans. Am. Inst. Min. Eng.*, Vol. XXI., p. 943.

is covered with a dome-shaped arch. Plows fixed in the roof stir the ore, and gradually urge it downward toward the circumference of the hearth. Careful arrangements are made for the introduction of pure air, strongly preheated by two Siemens' accumulators. As no assays or analyses are as yet made public, and as the purpose and conditions of the calcination at Shullsburg are totally different from the requirements of the copper metallurgist, it is impossible to institute any comparisons as to results. In calcining the pyrite in a mixture consisting of equal parts of pyrite and zincblende, in wheat-sized grains, Mr. Blake states that twenty tons per 24 hours is the regular duty of a 16-ft. furnace.

PYRITIC SMELTING.

In the United States this term is applied exclusively to a method of smelting ores, in which little or no carbonaceous fuel is used, the heat being derived mainly from the oxidation of the sulphur, iron, and other oxidizable constituents of the ores themselves. While still exciting great interest in this country, the expansion of this method has been seriously checked by three principal causes:

1. By the unsuitability to this method of the ores of the most important and active mining districts. It has, therefore, been mainly confined to the treatment of low grade precious-metal ores, the copper seldom averaging over 1% to 1½%, and being valued chiefly as a collector of the gold and silver. The ores thus treated have been mostly silicious, rich in zincblende and galena, and frequently in pulverized form, thus presenting a typically ineligible material for the process. Pyrite has generally been scarce and expensive, and added sparingly to the charge as a fuel.

2. By the great fall in the price of silver, which has cut off the major portion of even the ores that were available.

3. By our want of knowledge as to the loss in copper which is liable to occur in the slag when a matte containing over 25% of copper is made. This has kept the method from entering upon its proper and legitimate field: *i.e.*, the treatment of heavy, pyritic ores of copper, with or without precious metals.

Pyritic smelting is a process of very recent date. It may be said to have originated with John Hollway, who in 1878, at the steel works of Sir Henry Bessemer at Penistone, smelted Rio Tinto pyrites in converters without the assistance of any extraneous fuel, and demonstrated theoretically and practically the feasibility of the operation.

In 1881 F. W. Barnes of England erected, for a Vienna company, a bessemer plant on the Hollway system for the 5% pyritic ores of Majdaupek, Servia. The result was not a financial success, and there were serious, though not fatal, technical difficulties.

Tessier du Motthay's apparatus for the same purpose was erected about the year 1881 at Coumiens in France. It does not seem to have been successful.

In 1883 the bessemerizing of mattes at Éguilles in France was made a success by Pierre Manhès, and being introduced into this country by the Parrot smelter at Butte, has been practically the origin and inspiration of all our converter work.

In February, 1889, W. L. Austin applied for a United States patent for

an improved apparatus for the execution of pyritic smelting, and used the principles of the method, with technical success, on the heavy pyritic gold-bearing ores of Toston, Mont. This Toston company claims to have run the method successfully as long as a sufficient supply of ore could be procured.

In 1891 Robert Sticht built for the Boulder Smelting Company a pyritic smelter at Boulder, Mont. This was successfully run for some months, though on extremely difficult and unsuitable ores. It is now lying idle for want of ore at present price of silver.

In 1892 the Bi-Metallic Mining Company remodeled as a pyritic smelter the old La Plata lead-smelter at Leadville, Colo., and ran it with fair success for about a year. In 1893 it was completely remodeled, and three large pyritic furnaces put in operation. It is still in active operation, though using a very considerably modified form of the process.

Also, in 1892, the Summit Mining and Smelting Company erected a pyritic furnace at Kokomo, Colo., for a heavy, granular, decrepitating pyrite, containing gold and silver, but no copper. Ore containing even enough of the latter metal to clean the slags properly, say ¾% to 1% of the charge, was scarce and expensive, and the drop in silver rendered the enterprise unprofitable, the works closing in June, 1893.

There are now six furnaces in the United States equipped for pyritic smelting. Of these, only two are in operation, although probably nearly all would be running if the price of silver were as favorable as when the plants were erected. There is also some partial pyritic smelting going on at Tacoma, Silverton, and Deadwood.

TABLE OF PYRITIC FURNACES IN THE UNITED STATES.

Where situated	Kokomo.	Leadville.	Toston.	Boulder.
Number of furnaces	1	3	1	1
Size of furnaces at tuyères	33 x 140 in.	{ One 30 x 140 in. / Two 36 x 163 in. }	36 x 78 in.	36 x 96 in.
Capacity in tons per 24 hours as run	100	250	40	60

Pyritic smelting naturally falls into two main divisions:

1. The Austin method of pyritic smelting for highly pyritic ores, involving column-charging, high pressure of wind (2 to 3 lbs.), hot blast (1000° F. = 538° C.), silicious slags, little or no carbonaceous fuel. There are no examples of this method at present.

2. What I venture to designate "Compromise Pyritic Smelting," as actually practiced at all such works in the United States as are now voluntarily employing pyritic smelting at all; and partially, and often involuntarily, executed at numerous smelters that are simply running on rather a low percentage of coke and a sufficient volume of blast, to obtain some good from the heat generated by the combustion of the sulphides in the charge. This method, in its most pronounced form, is characterized by layer-charging, low pressure, and great volume of wind, a heated blast (though not necessarily so hot as in the preceding method), and the use of 1½% to 3% or more of coke, according to the amount of pyrites in the ore.

The first, or Austin, method demands a more or less complete separation of the

pyritic and the silicious or earthy portions of the ore. Austin found the two main difficulties in his pyritic work at Toston to be: *a.* The agglutination of the charge from the volatile atom of sulphur and from the mounting of the heat toward the tunnel-head, as well as from mechanical packing of the fine stuff. *b.* The impossibility of using a sufficiently powerful blast, especially when its temperature falls off at all, without forming large quantities of ferric oxide in front of the tuyères, which, of course, means bad slags. The first difficulty he proposed to obviate by his apparatus for column-charging, consisting of a water-jacketed central tube, reaching from the tunnel-head nearly to the smelting zone. The pyrites and smalls were to be fed into this central tube, while the earthy and silicious ores were to be charged into the annular space surrounding the tube, from which space the gases were also to be drawn off, as in ordinary blast furnaces with side flue. Very lately Mr. Austin has modified this plan by proposing to omit the central tube, simply feeding his pyrites and fusible ores in the center of the furnace shaft, while the silicious ores are charged around the walls. He will guard against the second annoyance, the formation of ferric instead of ferrous oxide in front of the tuyères, by the introduction with the blast of small quantities of liquid or gaseous carbonaceous fuel, thus heating the blast at the same time that he is producing a slightly reducing action. While Mr. Austin's opinions will carry weight on any point connected with pyritic smelting, it strikes me as a very delicate and difficult matter to produce a local reducing action, of just the intensity required, in an operation whose entire success and, indeed, existence, depends upon a powerful oxidizing influence in the furnace.

The second or "compromise" system of pyritic smelting is the only one that is or has been, for any length of time, in use in the United States or elsewhere. It has been practiced under such peculiar and diverse circumstances, on such different and varying ores, and under such pressure as regards immediate financial returns, that it is impossible, in a brief review like this, to attempt any exact record of the results obtained.* The percentage of the metals saved is also seriously impaired by the almost universal absence of dust chambers and settling flues, the marked unsuitability of the ores, and the usual shortness of the individual campaigns, which causes an abnormally large proportion of furnace-barrings and similar unprofitable material for retreatment. It should be positively understood by those interested in copper ores, that we have no record of any pyritic-smelting of ores for the purpose, or with the result of producing a *copper*-matte, and that we do not know what the loss from oxidation in the slags would be if we attempted to make a matte carrying 25%, or upward, in copper. The process has really only been used for gold and silver ores, carrying only enough copper to clean the slags. The ores treated have usually been of low, or moderate grade, ranging from 5 to 30 oz. silver per ton of 2000 lbs. (0.017% to 0.1%), and 1 to 10 dwt. gold per ton (0.000165% to 0.00165%). They have rarely averaged 1½% copper. The ratio of concentration has varied from say 5 of ore into 1 of matte, up to 15, or even 24, into 1. The latter extreme concentration has, naturally, been on ores with much silicious or earthy gangue,

* Those interested in the details, costs, etc., are referred to the forthcoming seventh edition of "Modern American Methods of Copper Smelting."

and very low in, or without, copper. The average recovery has been 80% to 95% of the silver, and 98% to 105% of the gold, there being nearly always an overplus of the latter metal in spite of the most careful determination of the gold down to one-one-hundredth of an ounce per ton (0.00003%). The slags have been generally satisfactory as regards their metallic contents, rarely exceeding one ounce of silver to the ton (0.0034%), and usually not a trace of gold. The copper also, in the slag accompanying the low grade matte that has always hitherto been produced, seems to be no higher than would be the case in ordinary matte smelting.

I think that, from our general knowledge of the subject, and more particularly from the actual results obtained at the works already mentioned, we may feel warranted in drawing the following conclusions.

1. That pyritic smelting is adapted to a great variety of ores, provided always that a certain proportion of them contain a sufficient supply of oxidizable substances to produce and maintain the required temperature. Arsenic, antimony, tellurium, and similar metalloids may furnish an important supply of heat, and *are more thoroughly volatilized than by the ordinary smelting process.* Heavy spar is not obnoxious, being thoroughly decomposed into barium silicate and sulphurous acid. Zinc and lead-sulphides in large proportions exert a very deleterious effect. The process requires no special apparatus beyond a good hot-blast stove and connections.

2. A small proportion of carbonaceous fuel, 1% to 3%, exerts a beneficial effect upon the operation out of all proportion to its calorific value. That it acts mechanically to some extent seems probable, as in two cases, to my knowledge, one-half of the coke has been replaced by an equal bulk of blocks of wood, without detriment to the process. Too much fuel simply abolishes pyritic smelting, which depends upon oxidation, and establishes the conditions reigning in the ordinary blast furnace. Of course the ratio of concentration falls at once, and the furnace becomes simply a remelting cupola.

3. A hot blast, say 1000° F. (538° C.), seems absolutely essential for comfortable and rapid pyritic smelting. Much sulphur and iron can be oxidized and the rate of concentration greatly raised by the proper management of a blast furnace, even if no hot blast is available. But this is not pyritic smelting. It is simply making use of the blast furnace as a calciner, and possibly gaining a little from the oxidation of the pyrites, as indeed we do in calcining furnaces. The difference in the calciner and the blast furnace is simply the difference in time that it takes to burn one pound of pyrites. In the calciner, this oxidation is slow, and the heat produced is mainly wasted up chimney, while in the true pyritic smelter it is almost instantaneous, the hot blast and high wind pressure causing the reactions to take place with extraordinary violence.

4. The cleanest and most satisfactory work has, thus far, been done on a slag containing 35% to 45% silica.

5. The losses in silver and gold are no greater—in gold possibly less—than in ordinary smelting.

6. The loss in copper when making a matte of 25% or over is not known. In making a matte below 20% the loss should be insignificant.

7. A small amount of copper, say a minimum of three-fourths of one per cent.,

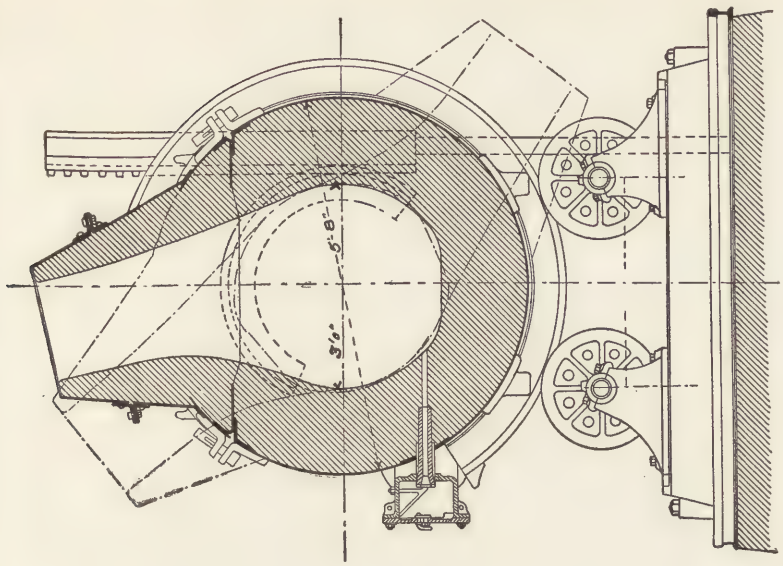
is essential to clean slags, unless either lead, bismuth, arsenic, antimony, or tellurium are present in such proportions, and under such conditions, as will enable one or other of them to take the place of the copper to a certain extent as a collector of values. But in any case, the extraction of silver is likely to suffer, though the saving of the gold may be as perfect as with copper. If running with a matte very low in copper, and otherwise so constituted that it has little affinity for the precious metals, it is of the first importance to keep the slags as silicious as possible. While this fact is known to every metallurgist of experience, it seems to be totally disregarded by the text books. An excellent example of this practice may be seen at the Argo Works, Colorado, where, in making exceedingly rich auriferous "bottoms" from pimple metal, the slag from the operation goes over the dump. This result is obtained by always keeping it decidedly silicious.

8. Iron pyrite loses about one-half its sulphur by volatilization, the remaining half alone acting as an available source of heat. Hence pyrrhotite is more valuable, weight for weight, than pyrite, and is a much more agreeable ore to smelt in a pyritic furnace, as we escape the agglutinating effect of the volatile atom of sulphur, as well as the hot tunnel-head likely to result from its combustion in the upper portion of the furnace shaft.

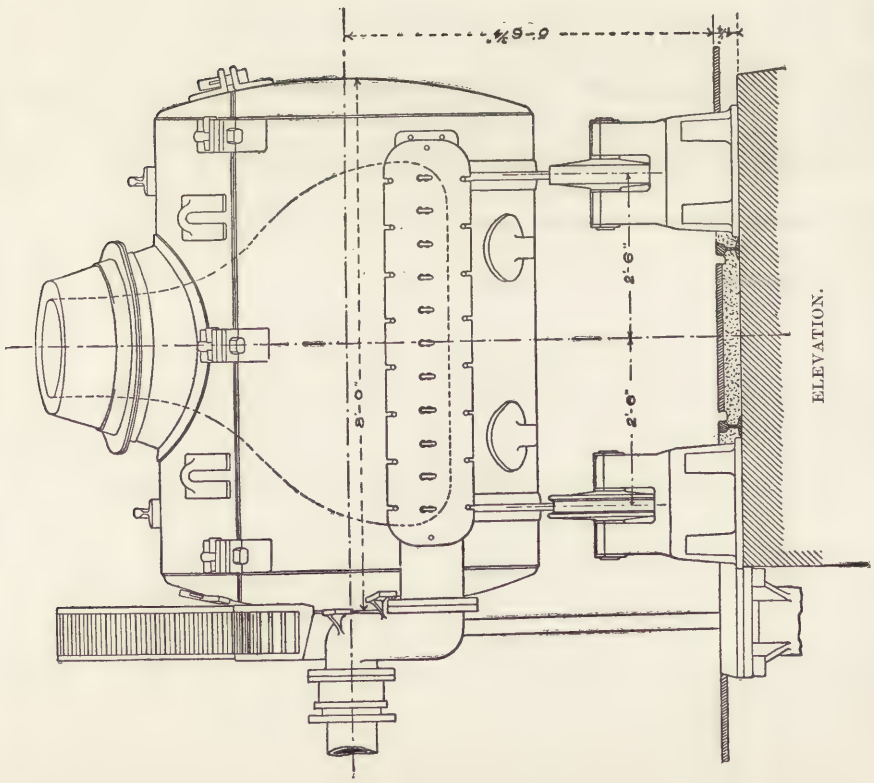
Matte is also an excellent material for concentration-smelting by the pyritic method. It may be charged in 20 to 50 lb. lumps, and, unless containing too large a proportion of the very basic sulphides of iron, or a considerable amount of magnetic oxide, will yield heat enough to smelt itself and the requisite silicious flux-ores. The iron of the sulphides yields by its oxidation about as much useful heat as the sulphur.

9. It has been established by a tolerably varied experience, that, under favorable conditions, pyritic smelting is more economical than the ordinary methods employed. In other words, it is more economical to utilize the sulphur and iron of suitable ores to smelt them with (even considering the cost of the required hot blast), together with a reasonable proportion of non-pyritous ores, where such are available, than to employ carbonaceous fuel to burn up this same sulphur and iron in a calcining furnace, and then to use still more carbonaceous fuel to smelt these calcines.

10. The rate of concentration—that is, the number of tons of ore that shall be put into one ton of matte—is almost entirely within the control of the metallurgist. This is the case even with highly pyritic ones. The cases in which unsatisfactory results have been obtained in smelting ores high in sulphur, the concentration only being from $1\frac{3}{4}$ into 1 to perhaps 3 into 1, are not examples of pyritic smelting at all. They are simply cases of changing the form of the ore by a mere melting, as one would remelt pig iron in a foundry cupola. Pyritic smelting (I am referring to "Compromise Pyritic Smelting," which is radically different from the Austin method, but is the only one in use at present) demands oxidation, which means the abolition of all boshes, or other decided contraction of the furnace-shaft toward the hearth, and the limitation of the coke used to the smallest possible quantity. It means slow smelting, that the cupola in its upper zones may act as a calciner, while opposite the tuyères it is operating, though feebly, as a bessemer converter, which means a light pressure but great



SECTION.



ELEVATION.

FIGS. 1 AND 2.—COPPER QUEEN TROUGH CONVERTER.

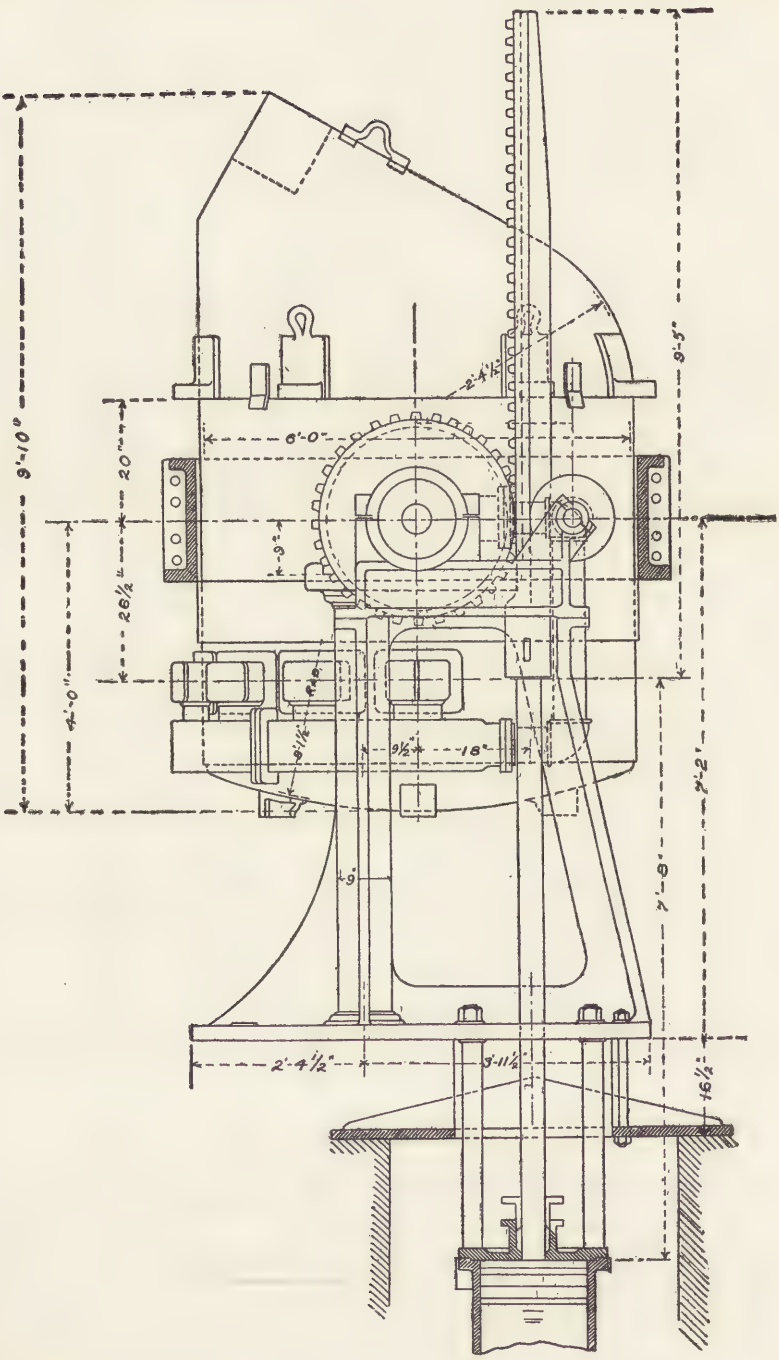


FIG. 3.—ANACONDA CONVERTER.

volume of blast, and a very long, narrow furnace; for with the slow rate of smelting we need great area of shaft, and with the light blast we cannot use a wide furnace, hence its length must be augmented. And, above all, it needs a thoroughly educated and experienced metallurgist, with a full understanding of the principles on which this operation is based, and which he must have learned from practice, as they are not to be found in any work with which I am familiar.

The Bessemerizing of Copper.—Converter practice, in the United States, is mainly confined to the treatment of mattes carrying from 48% to 60% copper. A large proportion of the matte bessemerized will run about 50%. Probably the most comfortable and economical material to work on, so far as the converter process alone is concerned, is a matte containing 55% copper. A matte poorer than this cuts out the converter-lining too rapidly, while a richer matte carries too small a percentage of sulphur and iron to keep the temperature up to the required point, and still provide sufficient heat for the necessary delays. For practical purposes, matte may be regarded as a mixture of cuprous sulphide (Cu_2S) and ferrous sulphide (FeS). Now, Cu_2S contains only 20% sulphur, while FeS contains 36.4% sulphur—nearly double as much. In addition, the iron in being burned to ferrous oxide, yields about as much effective heat as the sulphur. These facts account for the marked difference in heat production when blowing a rich or a poor matte. Below 45% the matte corrodes the lining of the converter too rapidly. A lining will seldom stand more than three blows of 40% matte, while it should outlast seven blows of 50% matte, and some fourteen blows of 60% matte. The obvious remedy would seem to be to add silica as a flux for the ferrous oxide, and thus save the lining, but it has never yet succeeded well in this country. If blown in as sand, silicious ores, or acid silicates, through the tuyères, it mostly refuses to combine with the ferrous oxide, preferring to float about on the surface of the bath, where it gradually agglomerates into hard, dry lumps; nor does it act more favorably when thrown on to the top of the charge. The only way in which the purpose can be at all effected is by adding silicious slag, which furnishes a certain amount of silica for the iron. But considering the small amount of silica thus provided, in proportion to the total weight of the added slag, the delay caused in using it, and the increased fall of converter-slag for treatment, it can scarcely be considered profitable. The great corrosion of linings is the weak point in converter work, and naturally points toward the use of either basic or water-jacketed linings; but, neglecting minor details, there are two main reasons why recourse has not been had to this very obvious plan. These are:

1. The exceedingly awkward necessity of using the lining as a silicious flux, as just intimated. A minor, but serious, annoyance in trying to introduce silica into the tuyères, is its persistent blowing back into the eyes of the workmen when they are freeing the tuyères.

2. The too great conductivity of these materials, which rob the lining of the heat that ought to be stored up in it in order to carry the charge through the period between the disappearance of the most effective fuel (FeS) and the completion of the process, and to keep the converter hot during the idle period of pouring and patching. Keller of the Parrot Works, in trying a magnesite lining, had to blow four hours and use considerable wood on a charge that should have come easily in 80 minutes, and without extraneous fuel.

There are, at present, five principal types of copper converters in the United States, differing, for the most part, in size, rather than in shape or management. These are:

	Outside Height. Feet.	Outside Diameter. Feet.	No. of Tuyères.	Matte Charge. Pounds.*	Pressure of Blast. Pounds.	No. of Blows Per 24 Hours.
Parrot converter	8½	5	18	3,000	10	14
Stalman converter	8	5	10	3,000	10	14
Anaconda converter	9.83	6	16	7,000	12	12
Great Falls converter	13	7	18	10,000	16	10
Copper Queen converter	7.25	5.67 x 8	11	7,000	5½	12

*These charges may be largely increased as the lining burns out.

The accompanying figures give a correct idea of their form, dimensions, and general construction, with the exception of the Great Falls converter. This is interesting mainly for its size, being 7 ft. in diameter and 13 ft. high, and weighing, with lining, some 48,000 lbs. When the interior cavity is enlarged by the corrosion of the lining, a second charge is sometimes added before the first one is blown higher than white metal, and the double burden is then blown up to blister copper. I have seen something over 10,000 lbs. of 99% blister poured from one blow, being cast direct into 200-lb. anodes for the electrolytic plant. The management of these large converters presents no serious difficulties, though it is more difficult to determine the different stages of the operation by the flame indications than in the smaller converters. The Parrot converter is illustrated in Figs. 6 and 7.

All of the above types of converters are now tilted by a hydraulic piston, armed with a rack that governs the pinion, or sector, fixed to the trunnion of the converter. The hydraulic piston and rack are usually vertical (Fig. 3), but may be made horizontal. Fraser & Chalmers have recently made a horizontal tilting mechanism where the piston is fixed, and the rack is on the upper portion of the traveling cylinder. This saves considerable space. (See Fig. 4.) This apparatus is made with small cylinders, and employs a pressure of 500 lbs. per sq. in. The ordinary pressure used is 200 to 250 lbs., but the geared pumps that are commonly furnished for this purpose are too weak and light for steady work, and recourse should be had to specialists in this work. The Copper Queen dispenses with pumps, and employs static pressure from a reservoir over 400 ft. above the smelter.

Ordinary converters are swung on trunnions, one of which is made hollow to admit the blast, the wind-connection being effected with gland and stuffing-box. In the Parrot and the Stalman converter, the converter is shifted by removing the caps of the trunnion-bearings, and lifting the body of the converter out of its place, with pinion still attached. In some of the larger converters the pinion and a short piece of trunnion-shaft are left permanently in the bearings, and the new converter-body is let down into place and attached to them.

The peculiar trough-converter erected at the Copper Queen by James Douglas (modified Leghorn pattern, see Figs. 1 and 2) has no trunnions, being merely cradled between two pairs of rollers, like a Brueckner cylinder, the blast-pipe being simply centered opposite the axis of revolution before the portion of the pipe descending to the wind-box is attached to the converter-body.

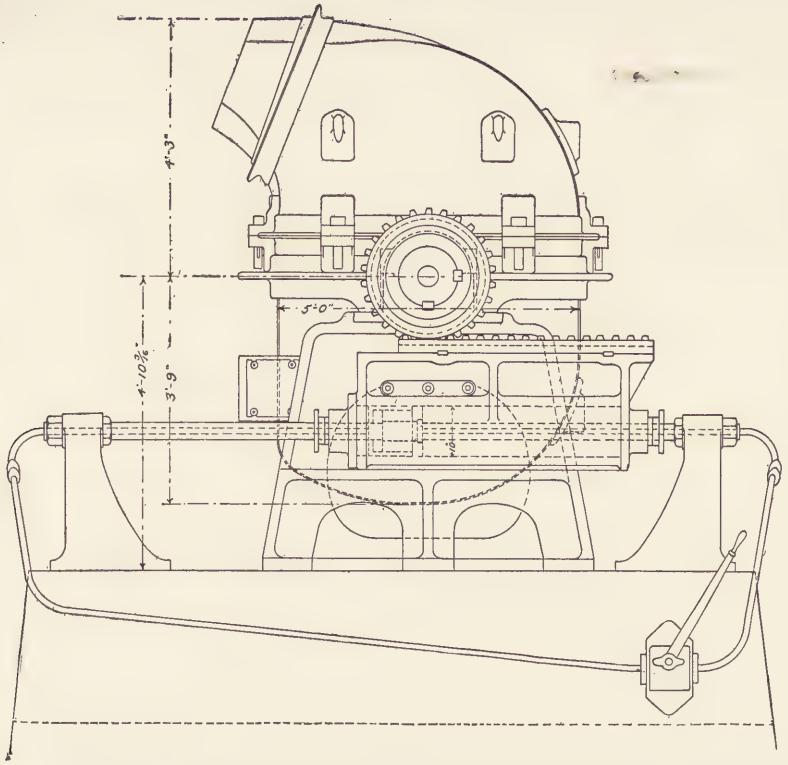


FIG. 4.—STALMAN CONVERTER, MOVABLE HYDRAULIC CYLINDER, HORIZONTAL RACK ATTACHED.

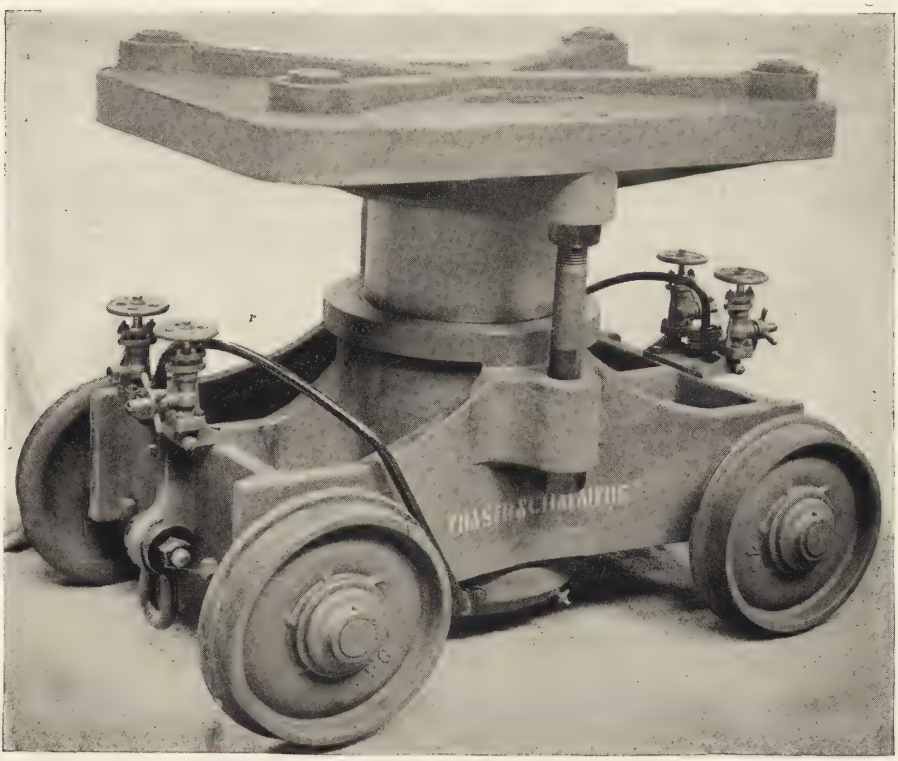


FIG. 5.—STALMAN'S HYDRAULIC TRANSFER CAR.

To face p. 224.

There are in this country five principal methods in vogue for lifting and replacing converter-bodies. These are:

1. By a hand, steam, or hydraulic crane, that lifts the old converter-body out of its frame, swings it to one side, and replaces it with a freshly lined one.

2. By a stout transfer-car running on a track beneath the converter, and having an independent frame provided with small jack-screws that can be screwed up or down at will. The frame is also adjustable laterally and longitudinally.

3. By a hydraulic transfer-car, as made by Fraser & Chalmers for Stalman. (See Fig. 5.)

4. By a vertical hydraulic cylinder beneath the converter, carrying a platform with a stout transfer-car, on which the converter rests as the platform rises. This is a common device at steel works, and may be adopted by the Messrs. Guggenheim at their new copper plant at Perth Amboy, N. J.

5. By an electric traveling crane running on a track longitudinally above the row of converters, and having a system of powerful blocks that not only hoist and lower, but also travel at right angles to the crane track. Engineer and electric motor ride in a cab on the crane. First used at Great Falls, Mont.

All of these systems, except the first and fifth, require also a jib-crane for taking the converter-body to pieces, the latter being provided with capstan-shaped lugs, around which a chain is wrapped.

The electric three-motion traveling crane is the most costly to instal, but by far the most economical and convenient in its working, where the plant is extensive. It can also be used for bringing fused matte to the converter, and for handling all its products and educts, whether molten or solid. The remelting cupola may thus be avoided.

Converter Linings.—A 5 by 8½ ft. converter, lined with an interior space 24 to 28 in. in diameter, lining reaching to within from 6 in. to 10 in. below tuyères, and running steadily on 50% matte, will require for lining and patching about 12,000 lbs. silica and 1700 lbs. clay per 24 hours. The clay must not be burned, nor should it ever be used in a frozen condition. Very impure clays are used at certain works with as much success as the best fireclays. The Copper Queen is using a highly graphitic clay, found near Benson, Ariz. The office of the clay is mechanical, its duty being simply to hold together the particles of silica that form the lining proper.

Both the chemical and mechanical condition of the quartz seem to be of importance. Sand, or friable sandstone crushed to sand, does not answer at all, the lining corroding and giving way in patches, while each tuyère opening forms a center of destruction that spreads with great rapidity. More solid quartz, at Butte and Anaconda, is also unsatisfactory if its silica falls below 98%. It also seems important to have many sizes of quartz grains in the mixture, that all the interstices may be solidly filled with this substance. Hence it is found that carefully classified quartz grains, no matter of what size, form an unsatisfactory material. The best results seem to be obtained by crushing the quartz to the size of ordinary peas, though it may be no drawback to have 10% of the grains as large as a hazelnut. The composition of the lining mixture is varied in the different portions of the converter, according to whether it has to withstand chemical, or merely mechanical action. The lining of the body of the converter

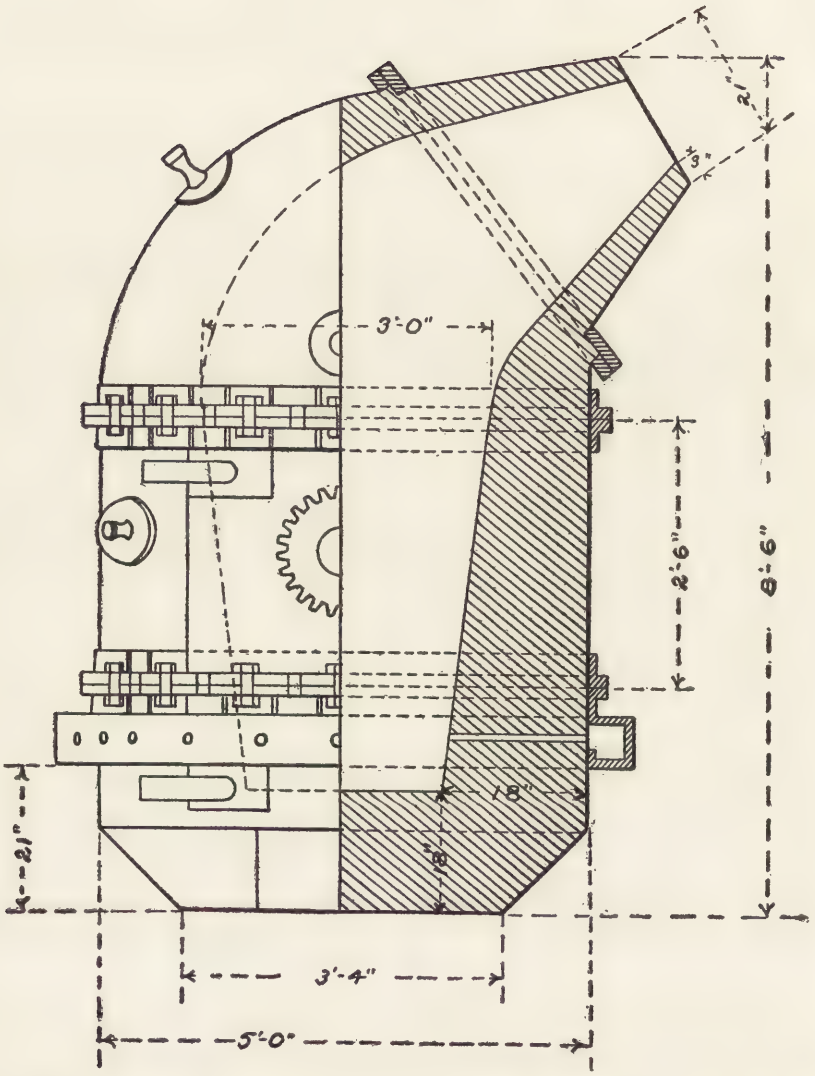


FIG. 6.—PARROT CONVERTER OF $\frac{3}{16}$ IN. SHEET STEEL. CAST IRON FLANGE.

may consist of 15% clay and 85% silica, while the upper portions of the lining contain 25% clay and 75% silica.

Three men will line a 5 by 8½ ft. converter in six hours. The care and skill with which the lining is tamped in, are the main factors in determining its duration. A "jumpy" stroke of the tamping-bar makes a yielding, elastic lining that is quickly washed out. Too finely-pulverized silica gives a similar result. Converters lined cold and dried slowly are more durable than those lined hot, with the free use of water to cool them off, and the consequent consumption of 50 to 100 lbs. coke and 4 or 5 cu. ft. of wood, to dry them rapidly. For the most economical and comfortable work, each converter-frame should have three bodies and two extra tops, as the latter need to cool completely for easy cleaning. The tuyère openings are generally made ¾ in. in diameter, and punched with an $\frac{11}{16}$-in. rod. A lining will average about seven blows on 50% matte before requiring thorough patching. On 62% matte the same lining will probably stand fourteen blows, while 40% matte would use it up to the same extent in three blows.

In a 5 by 8½ ft. converter a charge of 3000 lbs. of 50% matte will be blown to blister (98.3% to 99% copper) in 80 minutes. Fourteen charges are usually made per 24 hours. In a certain plant containing two converter-frames, and running on 50% matte, the monthly production averages about 1,400,000 lbs. blister copper. For every 100,000 lbs. of copper that is produced in excess of 1,000,000 lbs. per month, the foreman receives a bonus of 10c. per day, and the other men each 5c. This bonus has at times amounted to as much as 60c. per day for the foreman, and half this amount for the other workmen. Under the conditions last referred to, it takes 20 minutes to blow a 50% matte up to 80%, and an hour to complete it. A 60% matte is raised to 80% in about 10 minutes.

In the 7 by 13 ft. Great Falls converters it takes about two hours to blow 10,000 lbs. of 50% matte up to blister. A 14,000-lb. charge will scarcely take 25 minutes longer.

Serious explosions have occurred from the penetration of water into the leaky joints of subterranean blast-pipes.

Converter Slags.—When running on tolerably pure mattes, the composition of converter slag is mainly determined by the composition of the quartz and clay that form the lining. The matte furnishes little but protoxide of iron, the quartz little but silica, while the clay will rarely furnish important amounts of anything but silica and alumina. Moderate proportions of zinc and lead in the matte are volatilized. The slag, therefore, is mainly a silicate of iron, with a certain amount of alumina. The latter substance usually reaches 7% to 9%. The silica seldom varies far from 28% to 32%. The copper contents of converter slags, apart from a certain regular proportion of, apparently, silicate of copper, depends upon the matte granules that it contains, and is consequently very variable at different stages of the operation, increasing rapidly as the matte becomes richer. Apart from the matte grains, the normal, rich converter slag will run about 0.8% copper; but as these matte grains are always present, the slags as generally made at converters, and after deducting the buttons of rich matte that settle in the pots or ladle after the skimming of the slag, may be taken at about 2.75% copper. It is generally remelted with the ore, and as

the latter is usually in a more or less fine condition, and often silicious, the ferruginous slags from the converter are apt to be a welcome addition to the cupola, both chemically and mechanically.

At Great Falls, the converter slag, as poured from the converters into the ladle of the electric crane, is then poured direct into the hearth of one or another of their tilting, gas-fired reverberatory smelting furnaces, on top of an already nearly-melted charge of ore. A few minutes of sharp firing completes the fusion of the charge and the settling of the matte grains from the added converter slag. The reverberatory is then tilted by its hydraulic apparatus, and the entire mass of slag poured off into a launder, where, after passing a few settling traps, it is granulated by a stream of water and washed off into the rapid current of the Missouri River. The converter slag cannot be thoroughly decopperized in this manner, but the extraordinary saving in time and labor may be sufficient to offset the loss in copper. I have just suggested a modification of this plan for a foreign plant, whereby the slag from the converters is poured, by means of a traveling ladle, direct into the hearth of a reverberatory furnace, situated at one end of the converter shed. A large body of about 30% matte is always kept upon the hearth of this reverberatory, and after the charge of converter slag, or several of them, has been introduced, a couple of tons of crushed cupriferous pyrites is dropped upon the molten bath. I have found that this chills the slag just enough so that the pyrites can be intimately stirred all through the slag by a few moments' active rabbling, after which 15 minutes' sharp firing makes the whole charge ready to skim. It is well, however, to keep the hearth very full, and build up the skimming-door with a clay dam, so that the slag can be run off, instead of skimmed off, by gradually scratching down a groove with a hook, as the litharge channel was gradually lowered in old-fashioned cupelling. This gives a poor slag, and reduces the cost of treatment to very low terms, as astoningly little fuel is required in the reverberatory furnace, and the expense of the operation is nearly, or quite, covered by the treatment of the pyritous ore. The slag is granulated by water.

The Remelting Furnace for the matte has been too often described to require attention in this article, being simply a water-jacketed cupola with large movable crucible, in which is stored up molten matte in sufficient quantities to supply a full charge for the converters. It is a most extravagant and unsatisfactory process, requiring some 12% of coke, in order to heat the matte much hotter than is needed to melt it, so that it may not get too cold in the crucible while waiting to be used. It produces a certain amount of very rich slag that must be resmelted. It is a hot, disagreeable, and uncertain operation to plug the tap-hole of the crucible, when it still contains quite a head of matte. It takes three men per shift to run it, and altogether it seems a pity to be obliged to cool matte that is already melted and fit for the converters, and then remelt it again. Yet experience has shown it to be the most convenient practice where the plant is not especially arranged and equipped for a better method.

At Great Falls the tilting reverberatories pour their matte into the electrically transported ladle, which carries it direct to the converters, while the ore-cupolas are provided with circular 10-foot fore-hearths, which store up their matte until it reaches five tons or more, whence it is tapped direct into the same ladle,

and goes to the converters. But in this case also, the ore cupolas have to use a certain excess of coke to overheat the matte, that it may stay hot while waiting in the fore-hearth, and these large fore-hearths, though admirably managed at the works referred to, are a continual source of trouble and expense.

It seems to me more advantageous to make use of a reverberatory fore-hearth, as suggested, simply for settling purposes, years ago by Iles of Denver, and in regular use by James of Swansea and one or two other lead-smelters, for the purpose of not only thoroughly settling the slags from the ore cupolas, but for rendering the smelting system of ores and the storage system of mattes entirely independent of each other. This simple device saves the remelting cupola, enables the smelter to reduce the coke in his ore cupola to the lowest limit; entirely does away with the freezing-up or burning-out of fore-hearths, and the concomitant troubles with tap-holes; divorces the two incompatible operations of smelting ores, and storing molten matte for the converters; produces the cleanest possible slag; enables the smelter to run his ore cupola fast or slow, regardless of the rate of running of the converter, for he can always tap a portion of the matte from his reverberatory fore-hearth into sand-molds at one side, and add it again to the reverberatory, if he runs short of matte for the converters; and, perhaps most important of all, enables him to keep his matte for the converters at a constant standard of richness, by adding pigs of rich or poor matte, as the case may be, from an accumulated stock on hand. The only drawback is the coal required to give a slight fillip to the temperature of the reverberatory fore-hearth. Fifteen minutes fettling, twice a week, will keep the sides in order, and the hearth, if properly constructed of Stourbridge brick, as noted elsewhere, and never tapped so low as to leave it naked, will outlast the cupola.*

The Losses in Converter Work.—There has been very little accurate work done in this country toward determining the losses of copper, gold, or silver that occur in bessemerizing copper matte. All of the great smelters are run at high pressure, and with the object of making large and immediate financial returns. This forbids the separate preservation of by-products, and the radical stoppages, clean-ups, and stock-takings that are essential to the accurate determination of losses. A casual questioning of all the converter managers in the country will probably only elicit the reply that "they are not aware of any serious losses in the operation." Yet every one knows that there are losses, and heavy ones, and it is an open question how long the practice of blowing argentiferous mattes directly up to blister, with a heavy blast, is likely to continue. This is especially doubtful when the material is highly argentiferous, say half an ounce or more of silver to the percentage of copper (0.17%). The losses in ordinary bessemerizing are probably confined mostly to the silver and copper in the matte, and, assuming the presence of suitable dust chambers, occur mainly from volatilization.

I can offer only one exact statement as to the losses experienced in converting, and that totally without value as a record, for I am not at liberty to give my authority, though I know it to be highly intelligent, and believe it to be reliable.

* Bellinger of Butte has noted the curious fact that, when copper matte is run into pots, and then dumped in the open to cool, the conical or hemispherical masses will crack parallel to the vertical axis if the matte runs much below 50% copper, and horizontally, if it runs above 50% copper.

The opportunity arose from the necessity of treating a lot of matte containing so much bismuth that it was essential to keep it, and its by-products, entirely isolated. This necessitated a complete clean-up, both before and after its treatment, and advantage was taken of the circumstance to endeavor to arrive at the losses. It is not at all probable that the losses were affected one way or the other by the 2.2% of bismuth contained in the matte. I can obtain no average analysis of the matte that was treated. It contained, according to the settlement sample, 52.2% copper, 72.8 oz. silver, and 0.31 oz. gold per ton (0.25% silver and 0.001% gold).

There were produced about 228 tons (456,000 lbs.) blister copper of the following composition: Silver, 0.462% (134.7 oz. per ton); gold, 0.0021% (0.61 oz. per ton); arsenic, 0.074%; antimony, 0.021%; bismuth, 0.12%; iron, 0.063%; lead, 0.011%; copper, 98.91%—total, 99.6631%. Less than one-half of one per cent. (2220 lbs.) flue-dust was made, assaying 48.6% copper and 82.2 oz. silver per ton (0.282%). There was no perceptible loss in gold. The loss in silver was 5.6%. The loss in copper was 2 9%. The average wind pressure at the converter was 9 lbs. per sq. in. In a longer run, it is probable that these losses would be slightly lessened, but I have no doubt that they approximate the losses that are now being regularly made at American converter plants.

Experience seems to show that the principal losses, both of copper and silver, occur after all of the iron is scorified. The losses by volatilization then begin, and increase with the increased formation of metallic copper, and the diminution of the more oxidizable substances. I am informed that at Vivian's Works in Swansea they find a loss of about 2% copper in blowing white metal up to blister, and hence prefer to terminate the converter work when the matte has reached a 75% to 80% standard, and use ordinary methods for the removal of the residual sulphur. Here would seem to be an admirable opening for the use of Nicholl & James' excellent "Direct Method" of refining copper from white metal.* The losses of silver in this operation would, however, have to be carefully determined, where argentiferous mattes were concerned. Yet, in considering converter-losses of copper alone, it must be recollected that a 2% loss means only a loss of 40 lbs. of copper to the ton of that metal, or say $3.20 per ton of copper. It is a question whether, just at present, it would pay to interfere with the smooth and rapid current of the converter operation to save this entire amount. The loss of silver, however, may put a different complexion on the question.

The silver loss in bessemerizing leady mattes seems to be very great. This class of mattes is mainly produced by the silver-lead smelters, and have usually undergone a concentration smelting, by which most of the lead has been removed, and the mattes brought up to a high enough percentage in copper to make them a fit material for the converters. But they still contain 10% or more lead, and from 70 to 150 oz. (0.24% to 0.515%) silver. In bessemerizing these mattes, even at very moderate wind-pressures, the loss has been found, in some cases, enormous. A deficit of 33% silver has been experienced in blowing this matte up to blister copper.

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* THE MINERAL INDUSTRY, Vol. II., p. 269.

As metal losses by volatilization are believed to increase rapidly with the blast pressure, the trough-converter, with its light blast, seems to offer certain advantages. Raht, of the Philadelphia Smelting and Refining Company of Pueblo, has erected an ingenious trough-converter of his own design. James Douglas, president of the Copper Queen Company, has just erected at its smelter at Bisbee, Ariz., a trough-converter after the Leghorn pattern, but much modified and enlarged. (See Figs. 1 and 2.) I have his authority for stating that no difficulty was experienced in starting it a few weeks ago, and that it is running steadily and satisfactorily. In this apparatus, the converter is slightly tilted after metallic copper has begun to form, and the tilting is gradually continued as the superincumbent layer of matte decreases in depth, so that the tuyère openings are brought nearer and nearer to the surface of the bath. Thus the blast penetrates only the layer of matte, and does not disturb the metallic copper. The converter having a large area, and the tilting rendering the charge shallow, a very light blast suffices. Indeed, no heavy blast can be used, without hurling the molten contents of the converter out of the nozzle to a considerable extent. Douglas finds that 5½ lbs. per sq. in. of blast is all that he can use to advantage; and even with this light pressure, a single converter is turning out over 40,000 lbs. of 98.5% blister per 24 hours from 50% to 52% matte. The matte charge averages about 7000 lbs., and is completed inside of 1½ hours.

This work is very suggestive, and if it continues to live up to the reported results, may lead to considerable modifications in American converter practice.

The Production of Flue Dust in converter work stands in close relation to the blast pressure used. At one of the large Butte smelters, the average production of this material from the converters is found to be about 3000 lbs. for each 1,000,000 lbs. of copper made. This is 0.15% on the weight of the matte that goes into the converters. In these works, a peculiar product is found in the flues at some distance from the converters. It consists largely of zinc oxide, and contains about 23% copper and 40 oz. silver (0.137%), regardless of the grade of matte treated.

BLAST FURNACES.

The chief improvements in blast furnaces have been directed toward increasing the capacity, perfecting the mechanical details of furnace, fore-hearth, and blast connections, and substituting mechanical appliances for hand labor. The blast furnace is coming to be regarded less and less as a mysterious and uncertain apparatus, liable to all kinds of untoward and unlooked-for eccentricities, and whose moods are to be humored rather than curbed and directed. By practical smelters of to-day, the blast furnace is regarded simply as a convenient cavity, surrounded by water-cooled walls, in which coke is to be burned as rapidly as practicable, and as much properly fluxed ore is to be added as the fuel will carry. It has seemed to me for some years that in making their distinctions between the various types of copper blast furnaces the metallurgical text-books have totally neglected the one really important difference that exists. I venture to separate blast-furnace smelting, as well as the apparatus pertaining thereto, into the following two divisions:

1. Blast furnaces used simply for melting down ores or other material.

2. Blast furnaces used for partial oxidation as well as melting.*

1. Blast furnaces for simple melting may be compared, in the purpose of their action, to foundry cupolas for smelting pig-iron. Their object is to produce a high temperature opposite the tuyères, while keeping a cool top. The silica combines with the earths present and with the iron already oxidized by previous calcination of the ore, and the still existing sulphides are fused into a matte, with scarcely more loss of weight, or increase in grade, than arises from the escape of the loosely attached volatile atom of sulphur that is in such of the pyrite as has not been through the calciners, or from the formation of a certain amount of sulphurous acid from the reactions between oxides and sulphur compounds. These furnaces are, in general, characterized by a narrowing of the shaft toward the hearth, and an expansion upward toward the tunnel-head. Examples: Sudbury copper-nickel furnaces, Ore Knob cupolas, former Parrot ore cupolas, Rio Tinto cupolas, Mansfeld cupolas, nearly all lead-smelting cupolas run on the ordinary American system, also the Hartz precipitation cupolas.

2. Blast furnaces for partial oxidation as well as for fusion. This division is not sharply defined, metallurgists in many cases being unaware of the exact means by which they arrive at the excellent results that they accomplish. This is well shown in a recent case, where complaints were made that the matte grew poorer whenever they lined up their brick furnace, or whenever they ran with silicious slags, while it became much richer, and the slags, on exactly the same charge, grew more ferruginous and fusible at the end of the campaign, and just about when they were obliged to reline the furnace.

It was not difficult to see that, when the hearth was burned out, the furnace became a powerful oxidizer, sending the iron into the slag where it belonged, and not into the matte where it was unwelcome. When the hearth was restored, by lining-up, or by the building-up of silicious slags, resulting from a want of oxidation of the iron, to its normal dimensions, the furnace again became a mere melting-cupola. Examples of this second division are: Orford rachette furnaces, Montana Ore Purchasing Company's cupolas (to a certain extent), and nearly every cupola running with vertical walls, with no bosh, and with large volume and low pressure of blast. Very striking examples of this practice are the Ely, Vt., black copper cupolas, and Bartlett's former cupolas at Portland, Maine.

Copper-lined Furnaces.—Water jackets running on moist ores, or on dampened calcines, are often rapidly corroded by copper sulphates, the inner shell in the region of the tunnel-head becoming ruined long before the rest of the jacket has shown any signs of wear. Herreshoff and others have found it advantageous to construct the inner shell of copper.

One of the most perfect of recent copper-lined furnaces has been erected for W. A. Clark's United Verde mine in Arizona, for smelting roasted pyrites ores. The general design for the furnace was furnished by Joseph L. Giroux, the makers, Fraser & Chalmers, having worked out the details of construction

*The second division may seem to point to the intention of utilizing the sulphur, iron, or other constituents of the ore as a fuel, *i. e.*, pyritic smelting. But such is not usually the case. For many years, copper metallurgists have profited by the increased concentration and enrichment of the matte resulting from the use of suitably shaped blast furnaces and a proper manipulation of the blast, but seldom with any thought of systematically endeavoring to profit by the heat evolved by the oxidizing reactions that produced this concentration.

with their usual care and ability. It consists of three tiers of sectional water jackets, extending from the cast-iron base-plate to the charging door, which is 9 ft. above the tuyères. The middle tier of jackets has a bosh near the bottom, and the upper tier is so set that it tumbles in toward the tunnel-head. Thus the side-walls are contracted at the hearth and at the tunnel-head, and widen out at the middle of the shaft. The end walls are vertical. The inner shell of all the jackets is made of $\frac{3}{8}$-in. copper, and the outside shell of $\frac{5}{16}$-in. flanged steel, the two shells being stiffened by stay bolts that pass across through the water space. These stay bolts have caused no leakages. There is a partitioned wind-box containing 10 tuyère openings, the castings being of phosphor bronze. Each opening is provided with a deflecting nozzle, and a ball-valve to control the blast. The inside dimensions of this furnace are: Length, 90 in.; width at tuyères, 36 in.; width 5 ft. above tuyères, 61 in.; width at tunnel-head, 48 in.; width of water space in upper tier of jackets, 4 in.; width of water space in two lower tiers, $5\frac{1}{2}$ in; total weight of jackets, base-plates, I-beams for supporting brickwork, etc., 24,000 lbs.; total copper in furnace, 10,181 lbs.

There is a strong tendency toward the abolition of the customary housings and flues that encumber and darken the charging floors of most copper furnaces. The gases are now often drawn off laterally, either with or without a thimble and annular space, thus leaving the tunnel-head absolutely free and unencumbered. I have found no irregularities arise from thus drawing off the gases at one end of the furnace, below the charging floor. But in two cases I have heard complaints of a one-sided action of the furnace, the end on which the flue was situated running faster and hotter than the other end. In both these instances an unusually heavy blast is employed. A clear tunnel-head naturally suggests direct charging from barrows or cars, without intervention of the shovel. This is carried out very perfectly and satisfactorily at the lead-silver cupolas of the Pueblo Smelting Works of Colorado, where a charging car is employed, run by a wire rope over all the blast furnaces, and which automatically drops the charge into the furnace, no hand labor at all being required either for coke or ore.

Settlers.—The subject of making clean slag in the first instance by settling the matte properly, instead of resmelting a large amount of foul slag, is beginning to receive the attention that its importance warrants. I have long pointed out that, when running on a favorable mixture, 1% of slag was the maximum proportion that it should be necessary to retreat. But the proper employment of settling apparatus is still further complicated by the necessity of storing up molten matte in large quantities at the blast furnace for the intermittent supply of the bessemer converters. This is of especial advantage as avoiding the costly and wasteful remelting of the matte in special cupolas. It presents certain difficulties, however, to run a furnace advantageously as an ore-smelter, and yet to store up in connection with it two to five tons of 45% to 60% matte, and keep it hot enough for use in the converter at any moment. If the ore contains little copper, matte of this grade, and produced in small quantities, is certain to chill, unless extraordinary precautions are taken to prevent radiation from the fore-hearth, or unless the furnace is run with an inside crucible, which latter practice is likely to entail the delays and expensive repairs that we find at the Mansfeld

crucible furnaces. If the material smelted be selected ore or concentrates, rich in copper, as is usually the case in America, where the first matte goes direct to the converters, it is very difficult to control so large a body of molten regulus, and to prevent it from breaking out of the fore-hearth, which cannot well be water-cooled on account of chilling. The tap-hole is also likely to make serious trouble, as it has to be plugged when the converter is filled, and often with a strong head of matte behind it. At the Boston & Montana's smelter at Great Falls they have enlarged their fore-hearths until they have reached a diameter of 10 ft., at which point they find there is just enough radiating surface exposed to prevent the matte from breaking out, and yet not so much loss of heat that it chills up too rapidly. The matte is thus accumulated in 5-ton lots for the large converters, and the settling of the matte grains out of the slag is very excellent.

Encouraged by the views of Iles, of the Globe Works, Denver, who has given this matter much attention, and seeing a similar fore-hearth in successful operation under Christopher James' management at the Elliott Metal Company's Works in Wales, there have been lately planned some ore blast furnaces with fore-hearths in the shape of small reverberatory furnaces. These reverberatories have a bottom of neutral brick, and can easily contain 10 tons of molten matte, the slag flowing continuously over the skimming plate, while the matte is tapped periodically into the converters, as required. If the cupola makes matte faster than the converter can receive it, the excess is simply tapped into a sand-bed in the usual manner, and piled up until there is a scarcity of the same, when the pigs can be charged directly back into the reverberatory, and melted down in a few minutes firing. Or, by running the ore cupola faster than usual for a time, it can then be blown out for repairs, and the fore-hearth can be used as an independent remelting furnace, to keep the converter supplied with matte from the stock that has been accumulated.

The direct smelting of unroasted sulphide ores in the blast furnace is gaining ground, where the charge can consist of a mixture of concentrates rich in copper, and of rich silicious selected ores, that will yield a matte suitable for immediate converting. The main advantages derived from this practice are: 1. The saving of an expensive calcining plant. 2. A saving in fuel from two sources: *a*. The heat generated by the combustion of the sulphides. *b*. The easy fusibility of the sulphides, and the scouring and heating action of so large a proportion of matte. 3. The cheap retreatment of the converter slags, by using them as a flux for the ore smelting, where their mechanical action and easy fusibility will nearly or quite repay the cost of their treatment. 4. A clean slag, resulting from the large proportion of matte, and also from running a silicious slag, being enabled to do so by the mechanical action of the great quantity of matte, which assists a silicious slag to run freely.

In cases where the ore contains too little copper to produce a sufficiently rich matte from this raw smelting, a similar result can be obtained, and a calciner plant saved, by employing a concentration cupola, which receives the 20% to 30% matte from the ore cupolas, and, without calcination, brings it up to 50% to 55% by the use of a hot-blast, and a procedure analogous to pyritic smelting. Quite a proportion of highly pyritic ores can be used here as flux, and the slag can be

made silicious, low in copper, and fit to throw away; or, it can be made basic, ferruginous, and being then too rich in copper to throw away, can be used again in the ore cupolas as a flux. The cheapest way to return this slag to the ore cupolas, is to run it out in slag-pots, and when these are sufficiently cooled, to run them on to an ordinary ironclad platform car, on a sunken track, so that the platform of the car comes level with the floor on which the pots are run out. The dumping of the pots of slag on to this car will partially break up a cooled cone of basic slag, and this operation will be effectually completed when the slag is dumped down into the ore-bins above the ore cupolas, the car being switched on to a track running over the ore-cupola bins.

Where abundant water can be procured, it is usually economical to remove the ore-cupola slag by its agency. Certain devices, such as "the crescent-shaped jet," work admirably, but hardly seem necessary where a simple stream of water will do the same thing with ease and safety. The main point is to have sufficient velocity and depth of current, especially at the point where the stream of slag strikes the water. This granulates the slag instantaneously and thoroughly, and prevents explosions from the building up of a cone with cool exterior and hot center. This operation makes very little steam, and requires a fall of the tail sluice of from $\frac{1}{8}$ in. to 1 in. per foot, according to the volume of water and the amount of slag. Where there is no opportunity to thus wash the slag over a dump, the use of a bucket elevator is very economical, as the slag can be thus elevated and dropped on to a dump as high as desired, or into rail-road cars, where the water will flow away and the granules can be used as ballast. Besides taking regular and frequent ladle samples from the stream of molten slag, the little mound at the discharge of the sluice should be frequently panned and occasionally assayed, as any escaping matte granules will concentrate at this point.

Flue Dust.—Most modern cupolas are provided with convenient dust chambers, so arranged as to permit the automatic removal of the dust into cars running on tracks below the chambers. At W. A. Clark's United Verde smelter there is an entirely automatic device by which the escaping flue dust flows back to the tunnel-head in a continuous stream; this is said to not materially increase the total production of this material. But, with a constant tendency toward increase of blast pressure and decrease of coarse (first class) ore in furnace charges, the flue dust has increased, until at many smelters it averages 12% to 25% of the total weight of the ore. I have endeavored in one case to gain a rough idea of the extra expense caused by this item, and, though it is impossible to attain absolutely correct figures, I feel confident that the results here given are below the truth, especially at those works where the blast pressure is over 12 oz., and the flue dust is returned merely moistened with water. Production of flue dust from ore, 19.4%; blown over a second time, 20% of previous, 3.88%; blown over a third time, 20% of the last 20%, 0.77%—total flue dust, 24.05%; probably aggregating at least 25% of the entire original ore, and, counting handling, adding certainly 33% to the cost of the smelting operation. This will far more than pay for an original machine-screening and bricking of the smalls in the first place, besides enabling the furnace to run with a sufficient increase of speed and regularity to treat a considerably greater quantity of material.

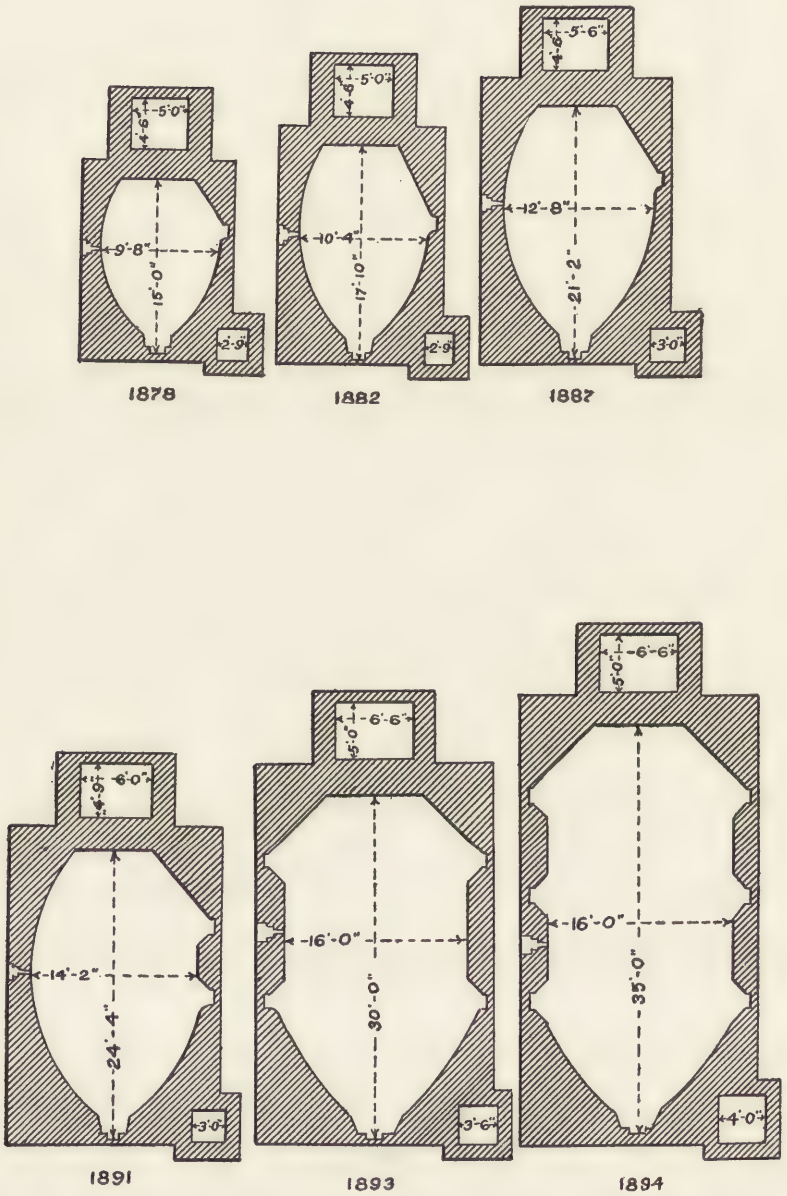


FIG. 8.—DEVELOPMENT OF REVERBERATORY FURNACES AT ARGO, COLO.

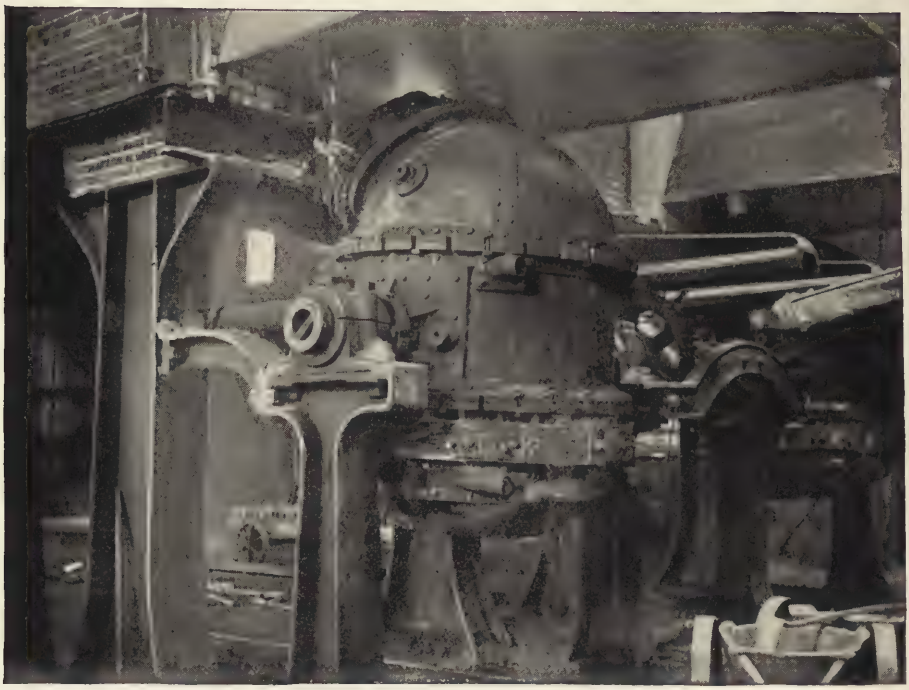


FIG. 7.—PARROT CONVERTER.

FIG. 9.—ARGO 35-FT. REVERBERATORY.

To face p. 237.

Making the fine ore into a mortar, with or without lime, is not an effectual remedy, as it crumbles rapidly in the furnace, if it does not fall to pieces before it gets there. The only radical and economical means that I know of, for American conditions of labor, consists in bricking the *almost dry* fines, with a little lime or copperas liquors, in an automatic brick press, run with very high hydraulic pressure, producing a brick hard enough to use at once, or after a few hours drying. This operation can be made entirely automatic and mechanical, and can be carried out at a cost that will leave a considerable margin above the cost of the ordinary treatment, besides increasing the capacity of the furnace as already stated.

REVERBERATORY FURNACES.

During the past few years a considerable increase has been made in the size of reverberatories, and in certain works their capacity has been augmented out of all proportion even to their increased size.

Richard Pearce, who has done more for reverberatory practice than any one that I know of, started, on about Nov. 15 of this year, a new reverberatory furnace, with hearth 16 by 35 ft. inside. It takes 25,000 lbs. of ore at a charge, and has been averaging four charges, or 50 tons ore per 24 hours, with a consumption of 13½ tons coal. One-half of the charge consists of hot calcines, the remainder being cold raw ores.

Through the courtesy of Mr. Pearce I am enabled to produce Fig. 8, which shows the evolution of the reverberatory since the erection of the Argo smelter in 1878. I have also prepared the accompanying table, which brings out still more strikingly the radical change in proportions between the old and new type of furnace, and which shows the gain, in various directions, resulting from the increase in size:

TABLE SHOWING DEVELOPMENT OF ARGO REVERBERATORIES FROM 1878 TO 1894.

Year.	Dimensions in Feet.			Area in Square Feet.			Ratio Between.			Ratio Between.		Per Cent of Hearth Area Lost in Corners.
	Stack	Fire-Box.	Hearth.	Stack.	Fire-Box.	Hearth.	Stack	Fire-Box.	Hearth.	Fire-Box.	Hearth	
1878....	2.75	4.5 x 5	9.66 x 15	7.56	22.5	105	1	2.98	13.9	1	4.67	28
1882....	2.75	4.5 x 5	10.33 x 17.83	7.56	22.5	139	1	2.98	18.4	1	6.18	24.5
1887....	3	4.5 x 5.5	12.67 x 21.17	9	24.75	198	1	2.75	22	1	8	26
1891....	3	4.75 x 6	14.17 x 24.33	9	28.5	265	1	3.17	29.5	1	9.3	23
1893....	3.5	5 x 6.5	16 x 30	12.25	32.5	402	1	2.65	32.8	1	12.37	16
1894....	4	5 x 6.5	16 x 35	16	32.5	481	1	2.03	30	1	14.8	14

The new 35-ft. furnace is charged from three hoppers, and is simultaneously skimmed from four doors, two on either side. The front door is not used for skimming. The slag, as at all the Argo reverberatories, flows out of the building through iron launders, and the matte is tapped about once in six days. The last tap, previous to Dec. 17, weighed 25 tons, and contained 37% copper. It resulted from 6 days' work, during which time about 300 tons ore were smelted, the concentration thus being 12 into 1. The Argo ores are by no means very fusible, containing much baryta, zinc, and silica, and the small matte-fall (about 8%) tends to make a furnace work sluggishly. The object of the process is to concentrate the gold and silver of the ore, and not to produce copper, except as an agent for collecting the precious metals. With the enormous matte-fall and

hot calcines in use at most of the Butte reverberatories, it is difficult to conjecture how much this furnace might smelt in 24 hours. The moral to be drawn from the success of these very large, angularly-shaped hearths is manifold. Among other hints, it shows us that there is no difficulty in making large bottoms stand; that an arch with a 16-ft. span is as easy to keep up as one of only 8 ft., providing it is properly supported at the skewbacks and allowance is made for its rising and settling with variations of temperature; that the hearth has not got to be made to conform to the supposed shape of the flame, but rather that the flame within reasonable bounds will heat any decently-shaped hearth by radiation; and, what will appear the most extraordinary fact of all, to Welsh furnace laborers, that a reverberatory can actually be skimmed at the side as well as at the front.

Some of the main interesting features connected with the Argo furnaces are:

1. Rapid charging and spreading of the charge, the latter operation being greatly facilitated by the large body of matte in the hearth.

2. Preheating of the air by conduction through channels in the brickwork of the furnace.

3. Rapid skimming through four doors simultaneously, and conducting the molten slag in launders outside of the building, where it is loaded on railway cars, for ballast, at a profit to the smelting company.

4. Tapping only once in 24 or more charges, thus keeping the hearth well covered with matte.

The practice at Butte, Mont., is of quite a different character, the charge there consisting mainly of calcined, pyritous concentrates carrying 10 to 22% (usually about 15%) copper, to which are often added sufficient dry silicious silver ores to make a slag containing 33% to 45% silica. Some of the reverberatory work at Butte is hampered by an injudicious method that prevails there of handling the flue dust from the blast furnaces. This unwelcome substance is made in large amounts in cupolas run on a finely divided charge, with low ore column and strong blast. The resulting flue dust not only contains an undue proportion of zinc, but also a considerable amount of ferric oxide, one of the most stubborn and disagreeable substances that can be charged into a reverberatory furnace. As a matte of about 50% copper is ordinarily aimed at, it follows that the concentration is only about 3½—at some works 2½—into one, the matte-fall thus being nearly 30% of the total weight of the charge. This makes a very favorable condition of things for rapid and easy fusion, and to this is also added the fact that 50% to 80% of the entire charge often consists of hot calcines. But even this is scarcely sufficient to explain the unprecedented capacity attained by the reverberatories of certain Butte smelters, such as those of the Montana Ore Purchasing Company and the Butte & Boston Mining Company, an average of 50 tons per 24 hours being sometimes maintained for many successive days, and some 48 tons per day for a run of months. I have late advices from a Butte metallurgist of undoubted reliability and accuracy stating that for several successive days a new reverberatory at one of the works above mentioned, with hearth 13 ft. 9 in. by 22 ft. in the clear, has averaged 73 tons (146,000 lbs.) per 24 hours, on a mixture of hot calcined pyritic concentrates and silicious ores.

This brief review cannot go into the details of the work, and I can only state

that, among the principal features of the Butte practice that determine this enormous increase in capacity of very moderate-sized furnaces are:

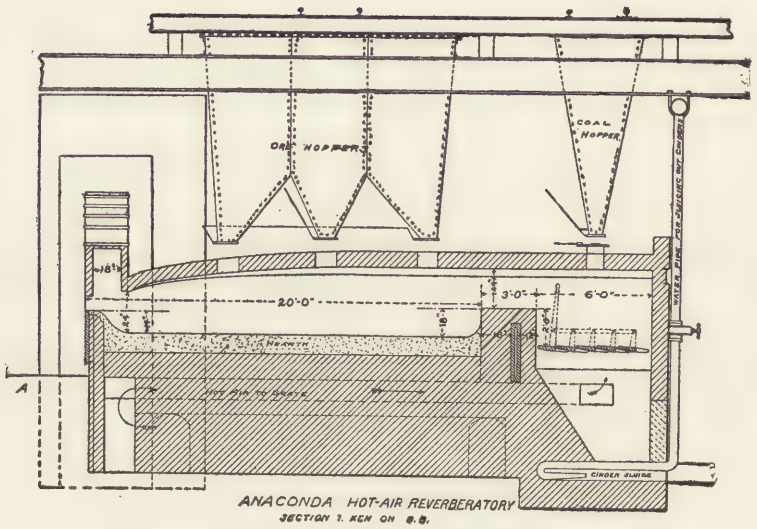
1. A more rapid combustion of fuel, say 10 tons per day, the capacity of the furnace, however, increasing in a more rapid ratio than the consumption of fuel. This rapid burning of coal is effected by: *a.* Enlarging the flue and stack areas considerably beyond what has been considered their normal proportions. Increasing the height of the stack beyond 60 or 65 ft. does no good here, nor have I ever found it of any advantage in any reverberatory work, except where there were hills or higher buildings in the immediate vicinity. *b.* Slightly enlarging the grate area, and keeping the live coals very close to the grate bars, thus totally abolishing the clinker grate, which was introduced to allow the use of a certain proportion of anthracite fines at Swansea.

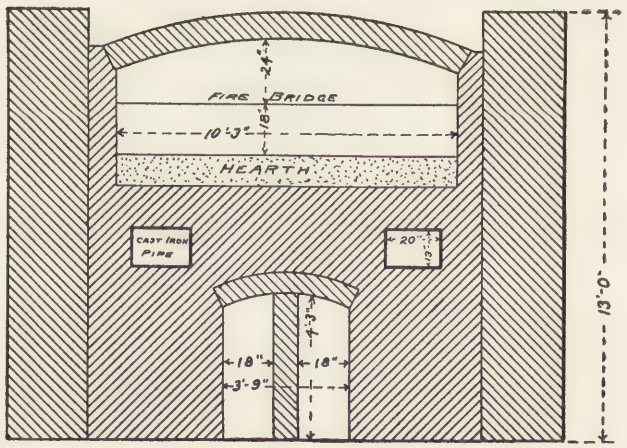
2. Endeavoring to keep the bottom of the furnace hot, instead of trying to cool it from the vault. A very large body of matte, 6 to 15 tons or more, is constantly kept on the hearth; and as the men are prevented by an iron plate from tapping too low, the bottom does not wear down unreasonably. Some metallurgists dread the effect on the hearth of this large body of hot matte. Its effect is in reality a protective one. It is true that, in smelting blister copper, its boiling, its high conductive power, and great weight tend to make it a somewhat severe substance on a sand hearth; but a large body of 50% matte is a very thorough protector for a properly constructed hearth, interposing an effective shield to the intensity of the flame, and, as a neutral substance, preventing the corrosive action of the ferrous oxide in the charge. With a large body of matte constantly in the furnace I have found less wear on a bottom after a year's run than had formerly occurred in a month, where the bottom was left naked every charge or two.

3. Lessening the intervals between charges, and also lessening the cooling off of the furnace. This is accomplished by rapid skimming and by dropping the fresh charge direct from hoppers upon the pool of molten matte in the furnace, which thus acts to disperse the hot calcines, which indeed are ready of themselves to spread in every direction like a semi-liquid substance.

It is hardly an exaggeration to say that from 30% to 50% of the time and fuel consumed in running reverberatory furnaces on the old principle was wasted in two directions that were totally useless and unnecessary. These were, and in many works still are:

1. In reheating the furnace after it has been unnecessarily cooled by: *a.* Slow charging through the side doors, instead of from hoppers. *b.* Slow leveling of the charge, from failing to keep a large body of molten matte in the furnace to assist in spreading the fresh charge. *c.* Careless grating, by which large holes are left in the fire. *d.* By allowing the calcined ore to cool before it is charged into the reverberatory. *e.* By omitting to provide a large opening in the side of the stack, above the flue, which can be opened whenever the furnace doors are taken down, thus checking the rush of cold air through the hearth, and confining the cooling to the stack, where this action is desirable. *f.* By too frequent fettling, and by wasting too much time over this operation. Furnaces running with moderately silicious slag should not require fettling oftener than every five days. A basic slag will cut a groove under the side-lining and the bridge-wall,





FIGS. 10 AND 11.—ANACONDA HOT-AIR REVERBERATORY. SECTION TAKEN ON C. C.

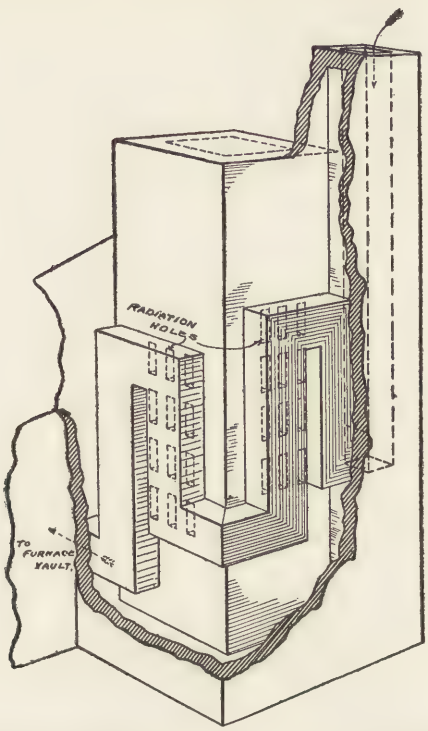


FIG. 12.—ANACONDA HOT-AIR REVERBERATORY. PROSPECTIVE SKETCH OF DOWNTAKE SHOWING DEAD-AIR CHAMBER AND HOT-AIR PIPE.

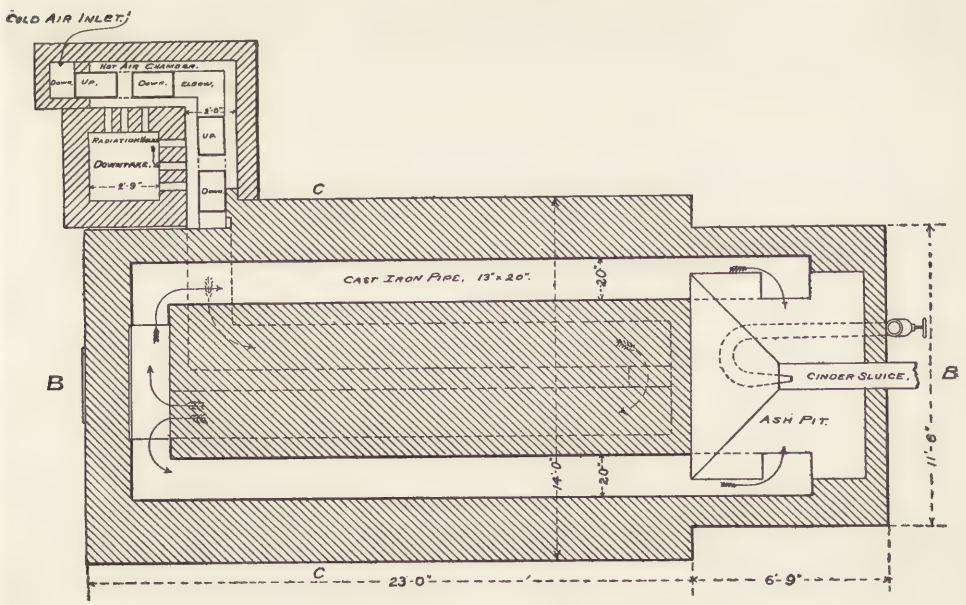


FIG. 13.—ANACONDA HOT-AIR REVERBERATORY. SECTION TAKEN ON A. A.

and when this groove has become deep enough to demand attention it should be rammed full of a mixture of 80% quartz (hazelnut size), and 20% raw fireclay. This should be thoroughly pugged together, and made into large balls ready for use, before the furnace doors are taken down. Two sets of men can clay the furnace simultaneously from the two opposite side doors; the one at the east door operating on the northwest section of the lining, while his partner at the west door is claying the southeast section, and vice versa. After this groove is once thoroughly filled, it can be kept from too rapid cutting by frequently throwing a heavy ridge of silicious ore up against it, and all around the edges of the hearth.

2. In waiting for the charge to be perfectly smelted before skimming off a portion of the slag; and in prolonged firing to "raise the charge off the bottom." It is proper and advantageous to skim the furnace as soon as enough of the charge is fused to give a tolerable bed of clean slag, and then the rest will "come" in much less time.

As regards the charge sticking to the bottom, there need be little danger of this annoying impediment if a large body of matte is always kept in the furnace. But where a sticky, slimy deposit has accumulated on the hearth and is gradually increasing, the quickest and cheapest remedy is a large charge of pyrites. The resulting great body of low-grade matte will clean out the hearth more quickly and thoroughly, and do the furnace much less harm, than attempting to remove it by the sole agency of long continued heat.

The Anaconda Mining Company has constructed a reverberatory furnace that presents certain interesting features. Through the courtesy of officials of this company I am enabled to present drawings of this furnace, which is designed to use an inferior coal, containing 20% or more of ash. (See Figs. 10, 11, 12, 13.) The coal is fed from a hopper direct into the fire-box, and the ashes are sluiced out of the hopper-shaped ash-pit by a current of water. The grates are shaken by an outside handle, like the grates of a pyrites burner. As will be seen from the cuts, the most interesting feature of this furnace is its unique and elaborate arrangement for preheating the air used for combustion. Two sides of the stack, for a distance of 15 ft. above and 6 ft. below the ground line, are enclosed by outer walls, an air-tight space being left between. Some radiation holes are also left in the stack-wall, to more effectually heat this air chamber. This hot-air space is traversed by a zigzag pipe, that receives its current of outside air at the point indicated in the cut. After traversing this pipe, the hot air passes backward and forward through the main vault under the furnace, and finally reaches the fire-box by traversing large cast-iron conduits on either side of the hearth. The air is reported to be heated to a temperature of 700° F. (371° C.) before it attains the ash-pit. Although the hearth is only 10 ft. 3 in. by 20 ft., the furnace is said to average 46 tons (92,000 lbs.) of hot Anaconda calcines per day. If this be the case, a very great advantage must be derived from preheating the air.

Gilchrist's Basic Hearths for refining copper have not equaled expectations. His basic hearth certainly absorbed arsenic and antimony to a wonderful extent and produced very excellent copper for the space of a few months, but the advantage was only temporary, and they gave up the impurities again to the copper with equal facility.

Aboriginal Metallurgists.

By James Douglas.

That there were metal workers on this continent before Columbus made his memorable voyage is questioned by no one, and that the native copper deposits of Lake Superior were one of the sources of supply is incontrovertible ; but there can be as little doubt that the copper ornaments and implements found in mounds and other Indian structures, and in Indian graves, are not all of pre-Columbian workmanship, but were brought by the Spaniards, English and French for barter, and were circulated as currency over the length and breadth of the continent. Copper and brass hawk-bells, for instance, were imported by the very first explorers, and are found in Indian depositories from the Isthmus to Labrador and from the Atlantic to the Pacific. A great deal of irrelevant argument, based on inconclusive facts, has been indulged in on the question. The last Annual Report of the Bureau of Ethnology—the twelfth—contains a very full and interesting narrative by Cyrus Thomas, of the work done in the exploration of Indian mounds by the Survey. In his summary Mr. Thomas seems to take it for granted that the copper, which is so smooth as to show no traces of the hammer, has been rolled, and is therefore of European manufacture. He adds :

" As a reference to all the articles made of sheet copper found in mounds and graves would be a tedious recital, and would require a personal inspection of all mentioned in order to determine the classes to which they severally belong, it must suffice to repeat what has been stated, that, as a general rule, the distinctive characteristics which determine the class to which they belong may be readily seen.

" As a matter of course no one claims that the mound-builders made implements and ornaments of native copper, and frequently hammered this copper into thin sheets with the rude implements of which they were possessed. What is here affirmed, and what, it is believed, can be successfully maintained by reference to, and inspection of, the articles, is that many of them, found in mounds as well as in ancient graves, have been made from sheets of copper so uniform and even as to forbid the belief that they were hammered out with the rude implements possessed by the mound-builders of pre-Columbian times. A careful chemical and microscopical examination of the various specimens might possibly settle the point ; however, as this has not been done, we must for the present rely upon inspection."

This rational and scientific line of investigation has, in fact, been followed by Clarence B. Moore in his " Memoir on Certain Sand Mounds of the St. John's River, Florida," published by the Academy of Natural Science of Philadelphia. Mr. Moore unearthed a number of copper ornaments, some of them of artistic and intricate workmanship. In endeavoring to determine the origin of these, he proceeded to follow the plan suggested, but not followed, by Mr. Thomas. He had chemical analyses made of the metal of which the buried articles were manufactured, and, for purposes of comparison, he had analyzed the native copper from the mines whence it is possible that the aborigines drew their supply of material. In the first part of the Memoir is given the

analysis of the copper from which was made a beautifully embossed breastplate found at Mt. Royal. It was returned as yielding: Copper, 99.258%; lead, 0.758% —total, 100.016%.

A mining engineer had led Mr. Moore to suppose that a native alloy of copper and lead existed in New Mexico, and he was therefore inclined to accept that locality as the source of the copper, and to draw a very interesting chain of conclusions from the assumed fact. But a doubt being thrown by competent critics on such a native alloy having been found either in New Mexico or elsewhere, or having been anywhere artifically made, the assay of the sample was repeated, and the lead found to have been in the analyist's reagents, and not in the sample. Mr. Moore seems then to have opened up an extensive correspondence with metallurgists as to what elements, found in any sample, would or might determine its origin. The general conclusion reached was that the presence or absence of arsenic and antimony in any considerable quantity was the most reliable indication; inasmuch as all European copper of the pre-Columbian and Colonial period must have contained considerable quantities of these impurities, having been almost, if not quite, exclusively mined in Spain, England, Germany, Italy and Scandinavia; whereas the copper from Lake Superior is practically free from them. The absence of these impurities would at least show that the copper did not come from Europe, and probably came from the Lake. Silver, being a constituent element of both Lake and Spanish copper, would not be so reliable an indication. Even its absence would not conclusively preclude the Lake as the source of supply, for Dr. Keller found scarcely a trace of silver in the analysis of copper from the Phœnix mine.

To ascertain the exact composition of copper in the native state a number of analyses were made. Dr. H. F. Keller, of Houghton, communicated the following:

	Tamarack Mine.	Kearsarge Mine.
Copper	99.8049	99.7627
Silver	0.0151	0.0183
Iron	0.0240	0.0223
Arsenic	Trace	Trace.
Silica	0.0193	0.0210
Total	99.8733	99.8243

Prof. Kidwell supplied the analysis of the metallic portion of copper ore from Isle Royale, where extensive aboriginal workings have always attracted the attention of archeologists: Copper, 99.9313%; silver, 0.071%; iron, 0.0069%; nickel, 0.0037%; arsenic, trace—total, 99.9690%.

Dr. Ledoux found in a sample of Osceola copper, furnished by Thomas Nelson: Copper, 99,9500%; silver, 0.0111%; iron, 0.0290%; arsenic, trace—total, 99.9901%.

The same analyst returned, as the contents of a sample of Franklin ore supplied by J. B. Cooper: Copper, 99.90%; silver, trace; iron, 0.018%; arsenic, none; lead, none; total, 99.918%; and of an ingot, said by Dr. A. E. Foote to be from a drift in Illinois: Copper, 99.930%; silver, 0.007%; iron, 0.014%; arsenic, none; lead, none—total, 99.951%.

Messrs. Ledoux & Co. also examined for arsenic and antimony and determined in three samples as follows:

	Quincy Copper.	Atlantic Copper.	Central Copper.
Arsenic	0.0010	0.0028	0.0016
Silver	0.0253	0.0012	0.0145

None contained even a trace of antimony.

When we compare the above analyses of selected samples of pure native copper from Lake Superior with the analyses of the metal of which some of the ornaments found in the St. John's River mound were made, the inference is almost irresistible that the copper came from the lake. For instance, Messrs. Ledoux & Co. obtained from two implements, which resemble copper punches:

Copper	90.730	99.720
Iron	0.034	0.044
Silver	0.023	0.015

Messrs. Booth, Garret & Blair returned from a similar implement: Copper, 99.89%; iron, 0.0057%; silver, 0.0012%.

On the other hand a number of fragments of sheet copper from the Mt. Royal mounds gave Ledoux & Co. Arsenic, 0.038%; iron, 0.170%; nickel and cobalt, 0.030%; silver, trace.

The high percentage of arsenic and the presence of nickel and cobalt would preclude the supposition of this copper being derived from the Lake. The same inference must be drawn from the analysis of two samples from Ohio mounds, which yielded:

Copper	96.31	Copper	99.91
Antimony	0.0070	Antimony	Trace.
Silver	0.0450	Arsenic	0.0026
Nickel and cobalt	0.0060	Silver	0.0196
		Iron	0.0233
		Nickel and cobalt	0.0080

The copper of the first sample was coated with carbonate, which could not be completely removed, hence the low percentage in copper. It is an interesting inquiry whence this copper came. That of both samples was probably drawn from the same source. It is too pure for the average European product, and too impure for Lake. It is quite possible, and indeed probable, that the Indians obtained small quantities of native copper from the outcroppings of sulphureted ore bodies in the Allegheny range, or elsewhere outside the Lake. Such copper would be found by them while mining the ferruginous cap for paint. Native copper is by no means of rare occurrence. It is found as a product of decomposition in nearly all copper ore bodies, and lumps of native copper are found interstratified with the red shales of the Quebec group.

Copper may likewise have been imported by the natives of the southeastern shore of North America from Cuba or other islands of the West Indies. That there was intercourse between the islands of the Caribbean Sea and the mainland

before Columbus' discovery, we gather from his meeting, when on his fourth voyage, with a large canoe propelled by 25 rowers, who came from some point to the west of Cuba, and whom he described as more highly civilized than the natives he had heretofore met. He specially mentions copper as an item of the canoe's cargo. Subsequent explorers mention the trade carried on between Mexico and Yucatan and the islands. The Baltimore Copper Works were originally built by the Baltimore & Cuba Copper Company, which relied for its supply on the Cobre mine in Cuba. Mr. Moore submitted native copper from the outcrop of this Cobre mine to several chemists, whose analyses agree with that of Messrs. Ledoux & Co., which we give below, because the same chemists made, at the same time, an analysis of a copper disc from Tick Island, which analysis we reproduce. They are almost conclusive as to the origin of at least a part of the copper used by some of our prehistorical metallurgists. For though the copper, silver and iron constituents agree with those in specimens of Lake copper, no Lake copper contains as much arsenic, and antimony is never detected in Lake.

	Copper Disc from Tick Island.	Native Copper from Cuba.
Copper	99.835	99.880
Silver	Trace.	0.0056
Arsenic	0.0089	0.0087
Antimony	Trace.	Trace.
Iron	0.072	0.019

J. A. Cooper, an authority not to be gainsaid, suggested to Mr. Moore an interesting physical test whereby Lake copper in its native state may be distinguished from the same after it has been melted. "You can readily determine," he writes, "the fact whether the mound copper is a native metal, or whether it has been smelted. Take a piece of the mound copper and hammer it thoroughly to harden it, then bend it double and hammer it down flat. If it is native copper, it will stand the test without a show of cracking, but if it is smelted copper it will break short in bending double. The fracture is entirely different. The fracture of native copper is more like that of lead when it is bent back and forth and finally broken." Mr. Moore very justly considers the presence of lead in the copper as proof of its artificial product and its European origin.

A native alloy of copper and lead, if it exists, is very rare, whereas the custom among smelters of throwing a pig of lead into a bath of refined copper, just before ladling it, to increase its softness and ductility, was common in the past, and has not yet been abandoned by all our copper refiners, though justly regarded as a pernicious practice. Another indication of the European origin of any copper article is the lower percentage of the copper contents than if it were made of native copper; for in the fifteenth and sixteenth century there is no reason to suppose that copper refined in Europe was purer than that made by fusion to-day, which seldom comes up to the grade of native Lake. He assigns, therefore, to European origin such a copper article as that extracted from a grave mound of the Hurons in Georgean Bay, which yields only 98.09% of copper and 0.300% of lead, and two copper articles from Iroquois graves yielding a copper percentage of 98.5 and 97.03 respectively, and lead in both cases. When the copper unearthed

proves to be brass or bronze, which is more often the case than is expected, its European origin is unquestionable.

That Lake copper may have penetrated into the southwest and far into Mexico in pre and post-Columbian times, as an article of barter, and among the possessions of migrating tribes, is probable; but it is more likely that the southern sections of the continent drew their supplies from domestic deposits. The Santa Rita mines of New Mexico were extensively worked for copper—much of it native—before the Gadsden purchase. More or less native copper of great purity is associated with cuprite in the surface ores of all the oxidized deposits of Arizona. But it is more than probable that the reduction of carbonates was accidently effected, and afterward practiced, by the aborigines of both North and South America. Lieut. Cushing* discovered some furnaces in the Salt River Valley of Arizona. They were in sections like a large slag-pot, and in the bottom was excavated just such a cup-shaped cavity as the smaller receptacle of a lead slag-pot. He found slag and charred grease wood in them. He thinks it fair to assume that they were used to fuse and collect the particles of copper which were disseminated through an earthy gangue. They were more likely used, as is also suggested, to reduce carbonates, which in that region are much more abundant than metallic copper. The Indians have always used the unopened interior leaves of the *Agave Palmeri* (Mescal) as food, after baking them in a very hot, stone-lined pit, without access to air; in these pits, however, there would be a reducing atmosphere. If stones of pure copper carbonate ever happened to be built into the walls of the pit, metallic copper would almost inevitably have been produced. The accidental discovery would have ever afterward been practiced as an art.

The sedentary tribes of the Southwest, who were almost exterminated by the devastating Apaches sweeping down on them from the north, and whose remnants in the present Pueblos and Zunis reflect but dimly the industrial status of their ancestors, were metal workers. Not only have traditions of the art, but some measure of the technical skill of their craftsmen in the working of metals, been transmitted to our own day. Lieut. Cushing, in the paper above referred to, tells us how, following Zuni practice, he was able to beat out with stone hammers annealed copper buttons into thin plates, and with such a rude implement as a deerhorn punch to trace in *intaglio* intricate figures in the copper plate thus made, cushioned on a soft pad of deerskin. Then, reversing the plate, he ground off with a stone the depressed grooves and liberated the clean-cut copper figures. In considering the capabilities of savages, we are liable to compare their average advancement with our own average—not their special abilities and special handicraftship. Nothing is more surprising than the exquisite taste in design and wonderful skill displayed by the squaws of such diverse races as the Digger Indians of California and the Apaches of Arizona in their basket work. Nor is any art among the Indians confined to a few individuals. It is almost a common heritage. No one acquainted with their dexterity could doubt the excellence of workmanship which the Indians might and do attain by practice in any special department. Accustomed by habit and training to be their

* *American Anthropologist*, January, 1894.

own builders and mechanics, Indians acquire extraordinary manual dexterity. The Indian boys at Hampton School, for instance, show much more ability in the use of tools than their negro fellow-scholars. The argument, therefore, so generally used against the aboriginal manufactnre of many of the copper ornaments and articles unearthed from the mounds of graves, that they display an excellence of workmanship incompatible with the stage of civilization attained by, and the tools accessible to, the Indians, must be accepted with great reserve.

The presumption derived from chemical analyses, as attempted by Mr. Moore, are very much more conclusive. The chief difficulty in applying microscopical tests, as suggested by Mr. Thomas, is the corroded surface of all the unearthed copper articles, and the tendency of metals, no matter how homogeneous, to oxidize unevenly.

The subject of aboriginal mining and metallurgy is one certainly of no little interest, especially to metallurgists. Accurate facts can be accumulated and correct deductions drawn with more certainty by chemists and metal-workers than by archeologists deficient in technical information and technical skill. And therefore the above observations and suggestions are submitted to the profession, in the hope that they may stimulate its members to examine analytically such metal articles of native use, or of native manufacture, as may come within their reach, and induce them to add to the store of facts, not fancies, which Mr. Moore has, with such praiseworthy zeal, begun to accumulate.

CRYOLITE.

CRYOLITE is a double fluoride of sodium and aluminum, containing 13% of aluminum, 32.8% soda and 54.2% fluoride. It is remarkable on account of its rare occurrence and the peculiar qualities which make it useful in the chemical industry.

Cryolite has been found in Colorado, but this locality has never yielded any commercial quantities. At Miask in Western Siberia it has been discovered but the deposits have never been fully explored. The discovery of a deposit of cryolite in Cape Breton, Canada, has recently been reported, but its extent and value have not been determined.

The entire supply of this mineral comes from the enormous deposit found many years ago at Ivigtut in Greenland. This deposit and the methods of working it were very fully described in THE MINERAL INDUSTRY, Vol. II. For nearly 40 years past it has been worked and the whole output shipped to Denmark and the United States. The operation is in the hands of a Danish company which uses a portion of the product in its own chemical factories at Oeresund in Denmark, and ships nearly all the remainder to this country, where it is used by the Pennsylvania Salt Company in its works at Natrona, near Pittsburg. The Danish and American companies absorb practically the entire output.

Cryolite is of value owing to its peculiar applicability to the manufacture of soda and it is almost all used for that purpose. Sulphate of alumina is obtained as a by-product in the process. A small amount has been used in the production of metallic aluminum and a small quantity also in the production of glass of a special quality; the glass made from cryolite is opaque but very beautiful in appearance, and is remarkable for its toughness. It is possible that other uses might be found for this mineral were it more abundant, but as the production is barely sufficient to meet the present demand and cannot well be extended, there is no probability of any new applications being made.

The accompanying table shows the imports of cryolite into the United States for a series of years. The variation in the quantity is due chiefly to the conditions of business; as the entire product is received and most of it used by the Pennsylvania Salt Company there is naturally but little change.

IMPORTS OF CRYOLITE INTO THE UNITED STATES.
(Tons of 2000 lbs.)

Year.	Tons.	Year.	Tons.	Year.	Tons.	Year.	Tons.	Year.	Tons.
1877.....	9,465	1881.....	7,932	1885.....	9,172	1889.....	9,085	1893.....	10,560
1878.....	7,070	1882.....	7,089	1886.....	9,190	1890.....	8,062	1894.....	9,986
1879.....	7,172	1883.....	8,113	1887.....	11,534	1891.....	9,783		
1880.....	7,690	1884.....	8,810	1888.....	8,180	1892.....	8,081		

The process of treating cryolite was described in THE MINERAL INDUSTRY, Vol. II. The ore as extracted from the mine needs no treatment beyond sorting it to remove rock and other impurities. It is shipped in the crude condition and is not ground or treated until after it reaches the works in this country or Denmark.

FERTILIZERS AND PHOSPHATES.

THE use of mineral products in the manufacture of manures and fertilizers is continually extending and their production is increasing. The phosphates take the first and most important place on account of their commercial value and general use, and to them the larger space is given in the following pages.

The tables of shipments and production given furnish statistics from 1890 up to date. For earlier statistics of the trade and for special information in relation to marls and phosphates, reference is made to THE MINERAL INDUSTRY, Vol. II.

COMMERCIAL FERTILIZERS.

Included under this head are a large number of articles varying more or less in their composition and used in many different ways by the farmers and planters of the country. The one which is perhaps most extensively used is known variously as acid phosphate or acidulated bone. This is composed of ground phosphate rock treated with acids to make it soluble and mixed by farmers with almost anything which is convenient; generally composted with barnyard manure, dead leaves, chips, wood ashes, cottonseed meal, oil-cake, fish scrap and salt. Where it is manufactured it is mixed in the factory with dried blood, tankage, kainit, nitrate of soda, muriate of potash, azotine and other ingredients. A very complete fertilizer is one made of ground phosphate rock treated with sulphuric acid and mixed with potash and ammoniacal matter; this is usually the highest priced and gives the best results. Acid phosphate is, in fact, the basis of most commercial manures, and it is from this that the cotton crops of the South get their best support; as long as this is the case the companies making an article of this kind will have a profitable business, for without commercial manures it is hardly possible to carry on farming on the extensive scale which prevails in the cotton belt.

According to the statistics furnished us by Mr. E. H. Willis, South Carolina makes about 25% of all the commercial manures made in the United States. Baltimore is next in importance to the South Carolina factories, while there are large plants also in Savannah and Atlanta, Ga., in Wilmington, N. C., in Wilmington, Del., and at other points. The following table gives as close an estimate as possible of the completion and production of commercial fertilizers in the United States for a series of years. It will readily be understood that an exact

statement is impossible, owing to the numerous points at which these fertilizers are sold and used, and the many small factories which it is difficult to reach :

PRODUCTION OF COMMERCIAL FERTILIZERS IN THE UNITED STATES.
(In tons of 2000 lbs.)

	Tons.		Tons.		Tons.
1886	1,099,500	1889	1,230,000	1892	1,365,000
1887	975,000	1890	1,250,000	1893	1,350,000
1888	990,000	1891	1,360,000	1894	1,600,000

The consumption of these fertilizers for five years past is estimated by Mr. Willis as below :

ESTIMATED CONSUMPTION OF COMMERCIAL FERTILIZERS IN THE UNITED STATES.
(In tons of 2000 lbs.)

States.	1890.	1891.	1892.	1893.	1894.
Alabama	40,000	55,000	40,000	45,000	80,000
Florida	20,000	25,300	20,000	35,000	50,000
Georgia	200,000	230,000	175,000	280,000	290,000
South Carolina	125,000	130,000	110,000	115,000	150,000
North Carolina	95,000	105,000	90,000	90,000	125,000
Tennessee	30,000	35,000	30,000	35,000	40,000
Kentucky	15,000	20,000	15,000	25,000	25,000
Mississippi	12,500	15,000	10,000	15,000	25,000
Arkansas	10,000	10,000	10,000	15,000	20,000
Louisiana	10,000	15,000	10,000	25,000	25,000
Texas	12,500	10,000	5,000	10,000	15,000
Virginia	70,000	80,000	55,000	50,000	90,000
West Virginia	25,000	30,000	25,000	25,000	30,000
New England States	105,000	120,000	100,000	105,000	120,000
Western States	75,000	80,000	75 000	80,000	125,000
Northern States	350,000	360,000	305,000	285,000	365,000
Total	1,195,000	1,320,000	1,070,000	1,235,000	1,575,000

The increase in 1894 was largely due to the increased area planted and the growing disposition to use increased quantities of fertilizers and to better cultivation of the land.

Greensand and Calcareous Marls.

By John C. Smock.

Greensand Marls of New Jersey.—Greensand or glauconite—the mineralogical name of the green grains which are the typical greensand—occurs more or less abundantly in the southeastern or upper part of the Cretaceous formations of New Jersey and in a belt of country stretching from the Navesink Highlands southwest to Salem and to Delaware Bay. The belt is 100 miles in length, varying from 5 to 15 miles in breadth. There are three well-marked formations or beds in which the greensand makes up the larger part of the mass and gives character to the deposits—as greensand marl beds. Below the lower marl bed there is a complete group known as clay-marls, wherein the distribution of the greensand is so irregular as to make it appear as if in pockets, or as clays containing greensand, but not to such an extent as to be designated marls. There are a few localities where the clay-marls have been dug. The marl belt is properly that of the outcrops of the three well-known beds. Generally the beds are exposed in the hillsides on the northwest border of the formation or belt and in the eroded stream valleys further to the southeast. The marl is dug in open pits

or "marl banks," as they are called, located on these outcroppings, or else where the covering of earth can be removed at moderate cost. There are marl pits on nearly every farm in the marl belt.

In local use the marl is carted directly to the fields where it is to be applied as a top-dressing, or to the compost heap where it is mixed with barnyard manure, lime, etc. Where the marl is dug on the farm the applications are usually heavy, amounting to 50 to 100 tons per acre in some localities. Where it is carted to farms outside of the marl belt or where the transportation is expensive the amount used is much less. The cost of extraction and of carting regulates in some degree the rate of using.

At Farmingdale in Monmouth County; at Birmingham, Vincentown and Fostertown in Burlington County; at White Horse in Camden County; and near Sewell in Gloucester County, marl has been dug and shipped by carloads to localities outside of the marl belt or district. The business of the marl companies shipping in this way has diminished considerably in the past two decades on account of the general depression in agriculture and the increasing use of the more active commercial fertilizers. The competition has not led to the disuse of the marls where they are to be had at low cost, and particularly where valuable marl is accessible on the farm or in the near neighborhood. The phosphate of lime, varying from 0.5% to 10%, the carbonate of lime, in a fine pulverulent condition, and the potash which they contain, make the best marls valuable and lasting fertilizers. They serve also as amendments, affecting beneficially the texture of the soil, if it is at all heavy.

The price of marl has a wide range, up to $1 a ton. The cost of digging and carting determine the cost where it is carried by teams, the railroad freight where it is shipped by carloads. Very little is sold at the maximum price, although the computed value as a fertilizer exceeds that amount. As the beds are from 10 to 30 ft. thick, the extraction by machinery is possible, and the cost has been reduced in this way in one locality, although the operations have not been altogether and continuously successful. Economy in extraction and in handling, with some method of concentrating the more valuable constituents, is greatly needed in order to promote an increase in the use of this natural fertilizer.

The companies shipping marl report a slight increase in the output for 1894 over that of 1893; the aggregate for these companies was in 1894 about 12,000 tons. While it is impossible to ascertain the exact quantity, owing to the way in which the beds are worked, it is estimated that the amount dug in the State of New Jersey in 1894 was about 110,000 tons. Of this total the larger part is dug in the eastern part of Monmouth County.

Marls of the Southern States.—Greensand marls occur in the extension of the belt of Cretaceous and Tertiary formation which runs from New Jersey southwest through Delaware, Maryland, Virginia, North Carolina, Alabama and Mississippi to the Gulf of Mexico; but excepting in Delaware and Maryland it is not known that they have been used as a fertilizer. Marls containing greensand are also known to occur in Arkansas and in Texas. Generally the deposits in the Southern and Southwestern States are characterized by an absence of the phosphate of lime in that proportion which gives value to the greensand marls of New Jersey.

North Carolina.—According to the Bulletin of the North Carolina Agricultural Experiment Station for November, 1894, marl is found in limited patches or beds in nearly all the counties of the eastern district of the State, but the outcrop is much more extensive and valuable in some sections than in others. The Cretaceous and Eocene varieties are mostly confined to the southeastern portion of the State, between the Neuse and Cape Fear Rivers, while the Neocene and later formations are much more widely distributed, and being nearer the surface, and so more accessible, have been much more extensively used, and are consequently better known than the earlier formations. They are found throughout a large part of the eastern region from South Carolina to Virginia. The western boundary of the main portion of these beds is very nearly represented by a line parallel to and a few miles west of the Wilmington & Weldon Railroad from Halifax to Goldsboro, thence southwest in a line parallel with the coast and about 65 miles therefrom, terminating at a point west of Lumberton. Marl is abundant and has been more or less utilized in 20 of the counties represented in this area, and beds have been located and samples analyzed from about 15 other counties, but the outcrops are not so extensive and useful.

There are are several varieties of marl in these deposits, the principal of which are Triassic, Cretaceous, Eocene, and Neocene—so called from the geological formation in which they occur.

1. The Triassic includes deposits in Wake County and southwestward. They are limited in extent and are not much used.

2. The Cretaceous includes the greensand formation, and occurs in the southeastern part of the State between the Cape Fear and Neuse Rivers, and is of the same formation as the greensand of New Jersey, but not as valuable because it has a smaller percentage of greensand owing to the large admixture of foreign material. In New Jersey the average percentage of greensand is from 50 to 90, while that of North Carolina is only from 5% to 10%. The outcrop is also comparatively small, so that for agricultural purposes the other varieties are of more practical importance.

3. Eocene marl occurs in about the same locality, and is found overlying the greensand. It is readily distinguished from the other by its outward appearance. The color is white or else a light drab or cream color, and where examined the fragments of shells or other organic remains are quite noticeable. The proportion of carbonate of lime in this marl varies from 40% to 90%.

4. The Neocene or shell marl is much more abundant and widely distributed than either of those previously mentioned. It is found in more or less abundance in nearly all of the eastern counties of the State, and is readily distinguished from the other varieties in that it is largely composed of undecomposed shells. The composition is very variable, containing on the average a less percentage of carbonate of lime than Eocene on account of the greater admixture of impurities. Some samples contain as high as 90% of sand, while others do not contain more than 10% to 25% of impurities.

So far but little use has been made of these marl deposits, but they are slowly being brought to the notice of the farmers of the marl belt and practically applied.

PHOSPHATES.

THE phosphate business in 1894 suffered somewhat less perhaps than most other industries from the general depression of business and the financial disturbance. The cause which affected the business most during the year was low prices, and several efforts made to unite the producers in maintaining prices and restricting production to the demand failed of final success, although the last attempt made among the Florida miners gives a fair promise for the future.

Two discoveries made abroad have threatened the phosphate miners of this country with a sharp competition ; the first is in Mexico, where it is said that deposits, large enough and rich enough to supply the Pacific coast, have been found. Very little, however, is known thus far of these discoveries, and nothing has been done toward working the deposits. In Algeria and Tunis, in North Africa, important deposits have been found which may become large competitors with our own producers in the European market. The production there has not been large thus far, owing probably to difficulties in the way of transportation. These deposits are fully treated in an article on a following page.

Our own phosphate beds are briefly referred to below in the alphabetical order of the States.

Alabama.—The deposit of phosphate rock which was said to have been found in this State between Selma and Demopolis has never been developed to any advantage. It is now said that deposits have been found in Jones Valley, in the northern part of the State, but their extent and value are as yet unknown.

California.—A phosphate deposit was reported as found near San Diego. A number of samples were sent East for analysis, but the result showed only a small proportion of phosphoric acid, with a very large percentage of carbonate of lime.

Florida.—The extensive deposits of Florida are well known and include all the varieties of those usually found—hard rock, soft rock, land pebble and river pebble. Mining has continued throughout the year with much activity and with no diminution in the product. As shown in the tables of shipments given below, the phosphate industry continued to be the most important single interest of the State, supplying a large amount of business to most of the railroad lines and to all shipping ports in the phosphate region. The figures given will show the comparative amount of this traffic.

SHIPMENTS OF FLORIDA PHOSPHATES.

Port.	1893.			1894.		
	Foreign.	Domestic.	Total.	Foreign.	Domestic.	Total.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Brunswick	34,186	.....	34,186	73,105	.....	73,105
Fernandina	126,439	.....	126,439	134,548	1,836	136,384
Punta Gorda	66,291	23,022	89,313	84,797	17,918	102,715
Tampa	75,827	36,531	112,358	124,120	45,321	169,441
Jacksonville	.....	.....	.....	.....	1,000	1,000
Savannah	28,675	.....	28,675	34,785	3,560	38,345
Railroads	.....	22,800	22,800	.....	20,000	20,000
Consumed	.....	12,661	12,661	.....	18,000	18,000
Total	331,418	95,014	426,432	451,355	107,635	558,990

The total shipments for seven years past have been as follows :

	Tons.		Tons.		Tons.
1888	813	1891	181,316	1893	424,457
1889	3,790	1892	354,327	1894	431,971
1890	52,381				

In the Florida phosphate mines there were no new developments of especial importance during the year.

North Carolina.—Some phosphate rock is mined and used in this State, but it is of rather a low grade. The North Carolina Phosphate Company is the main producer, and this company in 1893 sold 7500 tons, which was increased to about 9000 tons in 1894.

South Carolina.—In 1893 the amount of phosphate mined in this State which was consumed in the factories at Charleston, or shipped from that port and from Beaufort, was 556,883 tons. The cyclone which passed over the Southern coast late in the fall of 1893 destroyed nearly all of the river mining plants, which were the largest producers, inflicting a heavy loss upon the companies, and forcing those which were able to continue at work to renew their plants so that it was late in 1894 before mining was generally resumed. In spite of this, however, the production in 1894 reached 443,800 tons, less than it would have been but for the destruction, but still making a very good record under the circumstances. The production and shipping of phosphate from this State are shown in the accompanying table :

SHIPMENTS OF SOUTH CAROLINA PHOSPHATES.

	1893.			1894.		
	Beaufort.	Charleston.	Total.	Beaufort.	Charleston.	Total.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Foreign, by sea	156,691	275	156,966	111,944	12,417	124,361
Domestic, by sea	55,986	114,431	170,417	29,158	124,781	153,939
Domestic, by rail	12,500	47,000	59,500	12,000	46,000	58,000
Consumed	15,000	155,000	170,000	14,500	143,000	157,500
Total	240,177	316,706	556,883	167,602	326,198	493,800

The shipments reported for six years past, as given in THE MINERAL INDUSTRY, Vol. II., have been as follows :

	Tons.		Tons.		Tons.
1889	541,645	1891	572,949	1893	556,883
1890	586,768	1892	548,396	1894	493,800

The decrease in foreign shipments was much greater in proportion than that in home consumption last year.

The names of the South Carolina companies mining land rock are : Magnolia Mines, Horseshoe Mines, Gregg Mines, Charleston Mining and Manufacturing Company, St. Andrews Mines, Mount Holly Mines, Drayton Mines, Pou Pou Mines, Hertz & Warren Mines, Archdale Mines, Henry Dotterer Mines, Bolton Mines, Bulow Mines, Hertz & Dotterer Mines, C. McK. Grant Mines. The

river mining companies are two only: The Farmers' Mining Company and the Coosaw Company. All the old river companies outside of the Farmers' are now consolidated under the management of the Coosaw Company.

South Dakota.—Phosphate rock has been found in the "Bad Lands" of this State, but no explorations have been made to determine the extent of the deposits, nor so far as has been known have any analyses been made to determine their value.

Tennessee.—Much attention has been called to the new deposits in this State upon which mining has already been begun, and these deposits are fully treated in an article in the following pages.

Virginia.—Hard rock phosphates were found in Nelson County in 1893, and in Rockbridge County in 1894. Samples of this rock analyzed are of a high grade, but the deposits are badly situated for transportation, and as far as examined they are too small and inaccessible to be mined at a profit.

Phosphates of Tennessee.

By Lucius P. Brown.

Although the presence of phosphatic nodules in the Chattanooga black shale of Tennessee had been known for some years, it was only in November, 1893, that an enthusiastic but misguided prospector for coal stumbled upon the bedded deposit which is now being worked, and which was briefly noticed in The Mineral Industry, Vol. II.

These deposits lie in Middle Tennessee, mainly in the counties of Hickman and Lewis. Middle Tennessee consists essentially of a large "Interior Basin," surrounded by a rim of hills several hundred feet high, called the Highland Rim, through which a number of large streams cut their way in their course into and out of the basin. The rocks of the basin itself consist of Silurian limestones and shales, and it is intersected by ranges of hills identical with those forming the Highland Rim, the cap-rock of which is a Lower Carboniferous cherty limestone. Below this comes a blue shale, sometimes quite thick, called locally the "Harpeth shales," also of Lower Carboniferous age; and under these in turn come the Devonian black shale, or "Chattanooga shale," and the bedded phosphate deposits, for the two must be considered as one formation, so interbedded are they in many places, although ordinarily the phosphate forms the lower part of the formation. These rest upon either Upper or Lower Silurian limestones, the Upper Silurian in many places being absent. The Devonian shale, with its accompaniment of the phosphate layer or its representative, is very persistent in Tennessee, but in few places is the phosphate found sufficiently thick and rich to admit of its being worked.

The Tennessee phosphates are divided into (1) the nodular, (2) the bedded, (3) the white deposits, and (4) the Silurian beds.

1. The nodular phosphates are locally called "kidneys" on account of their shape, or "stink-stones," from the peculiar bituminous odor they give out on being rubbed or struck, and which is due to a considerable amount of organic matter in them. They occur usually in a well-defined layer of varying thickness imbedded in the top of the black shale, but sometimes scattered irregularly

through it. Nodules apparently identical with these are also found in many places scattered through the bedded phosphates. They are usually of a black or very dark gray color, but on long exposure to the air the carbonaceous matter, to which this color is due, oxidizes, and they become white and softer. They have a smooth surface, range in size from that of a marble to a diameter of a foot or more, and their concretionary structure is very marked. They run in content of bone phosphate from 55% to 74%, and are an excellent material for the manufacture of acid phosphate, but their small supply does not warrant mining them alone, and so they are made use of only as they are obtained in the mining of the bedded rock.

2. The bedded rock is divided into two main varieties, the blue and the gray, and these again into coarse and fine-grained. The blue is by far the more widely distributed, and this is indeed the general color of this rock. As a general rule the finer grained the blue rock the higher it is in grade, but this is not universal. It ranges as high as 80% in bone phosphate, and the unaltered rock usually contains less than 3% iron and alumina oxides. It also contains pyrite and 3% or 4%, usually, of organic matter. The oxidation of this pyrite and organic matter, along planes where the surface-water has penetrated, or on surfaces exposed to the air, has replaced the original blue color of the rock by a reddish-brown or gray, the color varying according to the amount of pyrite originally present. This change of course increases the percentage of iron oxide, but the coating of oxidized material is usually small in proportion to the unchanged rock. The coarser grained blue rock usually shows to the eye numerous small nodules, and shell-casts of gasteropods, mainly Cyclora; the finer-grained sorts show very few of these.

Both coarse and fine-grained gray rocks are quite rich in bone phosphate. The coarser grained is so far found only at the Totty's Bend mines of the Duck River Phosphate Company. It is very full of shell-casts of gasteropods, has little pyrite, and little iron and alumina oxides. Analyses by Bernard Dyer showed in two samples 74.29% and 74.55% bone phosphate and 2% and 2.24% iron and alumina oxides respectively. This forms the upper part of the deposit at this point, the lower being composed of a coarse blue rock running 65% to 70% bone phosphate.

The fine-grained gray rock is perhaps least in amount of any, being found in comparatively thin seams, and in only a few places in the field. It is not so well-known as the others as yet, but analysis seems to show that it will run from 75% to 84% bone phosphate, with a low content of iron and alumina.

All these varieties of the bedded rock occur of varying thickness, but it does not usually pay to work a seam of less than 18 in. in thickness, nor is any rock of less than 60% bone phosphate shipped from the field, and very little under 65%. Of rock running less than 60% bone phosphate there is a very large amount in Tennessee. The principal impurity in this low-grade rock is sand, and as it reaches a thickness of 5 ft. in places (which would run 45% bone phosphate) it may be possible on account of the cheapness with which it could be mined to utilize this after awhile by manufacturing it at the mine, if cheap transportation is provided. The bedded rocks are all undoubtedly Devonian, as is proved

by the finding in them of the remains of large fishes, probably allied to Dinichthys.

ANALYSES OF REPRESENTATIVE MEDIUM AND HIGH-GRADE TENNESSEE PHOSPHATES.

Constituents.	Coarse-grained Gray Rock. Lehmann & Glaser.	Fine-Grained Gray Rock. L. P. Brown	Fine-grained Blue Rock. L. P. Brown.	Fine-grained Blue Rock from Another Mine. L. P. Brown.	Nodules. L. P. Brown	Coarse-grained Blue Rock. Average of four Samples. L. P. Brown.
Phosphoric acid	33.73	35.69	32.67 (*a*)	35.02	30.64	31.63
Phosphate of lime	73.63	78.80	72.23 (*a*)	77.63	67.14	68.95
Oxide of iron and alumina	2.06	2.28	2.14 (*a*)	4.10*b*	3.42	.....
Iron sulphide (pyrite)	2 09	1.95	4.52 (*a*)	.66	2.27	.....
Carbonic acid	3.54	.....	1.84	1.77	.....	.....
Equivalent to lime carbonate	8.01	.....	4.20	2.66	.....	.....
Moisture	.25	1.27	1.40	1.68	.48	.....
Organic matter	1.13	.....	.....	.....	.....	.....
Lime	47.18	.....	47.37	.....	.....	.....
Magnesia	.23	.....	.....	.....	.....	.....
Sand, etc	2.88	.....	2.52	2.22	5.15	.....
Undetermined	.....	.....	.....	.....	.....	.....

(*a*) Average fifteen samples drawn at different times from same mine.
(*b*) Sample contained an undue proportion of brown (weathered) rock.

3. The white phosphates, which have been very well described by Mr. C. Willard Hayes,* are of two kinds, brecciated and white bedded. They occur in Perry County, some 30 miles west of the blue-rock region, are of different geologic age from the latter, and closely resemble Florida hard rock, but are of too low grade, so far as yet explored, to be of economic importance.

4. The Silurian phosphate occurs in several places as a regular bed of varying thickness in the Trenton limestone. It resembles quite closely, both in structure and in fossils, the coarse-grained Devonian phosphate, but contains only about 40% bone phosphate, and is not therefore of economic importance. It is mentioned here only as a possible source for the richer Devonian beds above it. A similar rock has been noted in Kentucky.†

Distribution and Technology.—While the estimates made in the first flush of the excitement on opening these fields must undoubtedly be very much reduced, development has not yet gone far enough to make it possible to give any figures as to the probable amount of rock in sight. Enough is known, however, to make it certain that the operators now in the field have enough to last them for several years to come, and that there is a considerable amount of good land still unopened. This is without counting the rock below 60%, of which there is a very large amount. The beds now worked vary in thickness from 18 to 40 in., and a bed of about 2 ft. in thickness (which is probably near the average) would give about 7000 tons to the acre.

The rock now mined is obtained either by simply stripping off the overburden by hand-labor, and then quarrying out the phosphate in big lumps (which must, however, be small enough for one man to handle easily), or by mining it in drifts like coal, by the pillar and stall system. In cases where the overlying stratum makes a good roof, not requiring much timbering, it does not pay to take off more than about 10 ft. of overburden. Since the phosphate beds for the most part

* *Trans. A. I. M. E.*, March, 1895.
† *Geol. Survey of Kentucky*, N. S. Shaler, Director, 1878, New Series, Vol. IV., p. 65.

crop out on the hillsides, just as coal seams do, the stripping of the overburden is a simple matter, very different from raising it to the surface on level ground.

As the beds all lie from two to eight miles from a railroad, the rock must, for the most part, be hauled to it in wagons over country roads. This, however, has been avoided by one company, which wagons its rock to Duck River and floats it down on barges to the railroad, the haul thus being reduced to 1¾ miles, the distance from the mines to the river bank. Other operators propose to overcome this difficulty either by means of tramways or by building branch railroads to their mines.

The rock comes from the mines in large lumps, and sometimes requires no further preparation. The general practice, however, is to break it at least small enough to pass a 2-in. ring, either with a stone-crusher or by hand. A great deal of the rock does not require to be freed from adhering clay and sand, but a good practice is to screen it with a revolving screen of about ¼-in. mesh as it comes from the crusher, which removes a considerable amount of these impurities. The material that passes the screen can then be ground to 60 or 80-mesh and sold to the farmer for direct application, or to small manufacturers, as it usually runs over 60% bone phosphate. The rock as it comes from the mine is comparatively dry, and becomes drier after exposure to the air for a few days, so that no drying apparatus is required. Only one dryer has been put up in the field, and this is for the purpose of drying when wet by rain or snow; it is very simple, and uses only the exhaust steam from the engine.

At present there are four companies at work in the field, all organized during 1894, viz., the Southwestern Phosphate Company, the Swan Creek Phosphate Company, the Duck River Phosphate Company, all with headquarters at Nashville, and the Tennessee Phosphate Company, whose main office is in Baltimore. Two of these have erected crushers and storage-bins, the others break their rock by hand. Since no special preparation is required, the capacity of the two former companies is limited only by that of their crushers to break the rock, or about 250 tons per day for each, and it is hardly probable that they will soon want to exceed this production. Of the other two, the production is limited only by their ability to procure the necessary labor, and, indeed, this is the most important question with all the operators, so that it would be unsafe to attempt any estimate as to the total capacity of the field at present, for the operators have not become as yet thoroughly familiar with the conditions under which they work. This also prevents the giving of trustworthy figures of cost of getting out the rock.

So far as can be ascertained all the varieties of the bedded rock work up into a good acid phosphate. The product usually admits of being dug out of the "dens" in from 24 to 48 hours, in a dry, friable condition, and can be sacked at once. The sulphide of iron contained in the rock is in the form of pyrite, and therefore practically unalterable; furthermore, experiments by McCandless and others have proved that it is inert in the acid phosphate. Seven analyses of acid phosphate made from high-grade Tennessee rock by one manufacturer show an average of 17.35% available phosphoric acid.

Shipments of rock up to Jan. 1 were all to interior points, and aggregated 17,384 long tons, valued at $54,112.50. Low prices toward the latter half of the

year, combined with lack of transportation facilities, have tended to restrict development and production in this field. The second of these has been the most serious difficulty, but will probably be overcome in a few months. Organization would undoubtedly do much to correct the first. As it is, however, the miners have done remarkably well under the circumstances. They already control, as would be expected, the interior markets and are reaching out for European orders. The cheapening of raw material consequent upon the opening of this new source of supply will probably also increase the consumption of acid phosphates in the Northern and Northwestern States, so that the prospect for this field seems to be good.

The Phosphates of Tunis and Algeria.*

By D. Levat.

Several years ago the existence of phosphate of lime was recognized in the rocks of Algeria. M. Phillipe Thomas confirmed its presence in considerable proportions in the Lower Eocene (Suessonian) southward from Tell in the Province of Algeria; but previous to this M. Le Mesle had described certain fossils of Cretaceous age (Albion) containing a considerable quantity of phosphoric acid, found at Djebel-bou-Thaleb, near Setif in the department of Constantine. M. Tissot in 1878 held that the presence of phosphates in certain localities possessed a more general signification and expressed the opinion† that workable deposits might be found.

M. Phillipe Thomas, having completed an official visit of scientific inquiry and research to the Regency of Tunis, published a report‡ upon the phosphate deposits of southern Tunis in 1886. This geologist had minutely examined the deposits of the neighborhood of Gafsa and clearly foretold their persistence through the entire region of southern Algeria, which extension has more recently been proven.

Plate I., which is given herewith, is a reproduction of a geological map made by M. Tissot, of the Province of Constantine, combined with another of Tunis made by M. Aubert. It represents the surface geology of the three periods: 1. Jurassic, of which there are but few occurrences; 2. Cretaceous, without distinction between the Upper and Lower epochs; 3. Lower Eocene, at the base of which the phosphate deposits occur.

The development of the eocene in Algeria is much more complicated and variable than in the classic regions. There is, however, at the base of the eocene a prevailing character, exhibiting a horizon of marls, distinguished by the presence of silex, more or less large in size and possessing a white exterior with blackish interior. These are considered by the natives to be fossilized bones, and called by them "Oum-el-Adam" (mother of bones); this similarity in designation is interesting when we consider the proximity of these flints to the phosphate beds containing many fossil remains; although it may be merely a coincidence.

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* Communicated to The Mineral Industry by Mr. D. Levat, as the substance of a paper he had prepared for *The Annales des Mines.*

† *Géologie et minéralogie de Departement de Constantine*, Paris, Exposition Universelle de 1878.

‡ P. Thomas, *Association francaise pour l'Avancement des Sciences*, Congres du Nana, 1886.

PLATE I.—MAP OF PHOSPHATE REGIONS OF TUNIS AND ALGERIA.

The general geological characteristics of the phosphate deposits in Tunis may be briefly examined.

The Lower Eocene.—This horizon of the eocene series is indicated upon the map by *e*; it is represented in Tunis and in the southeast of Algeria by the silex marls already referred to, which rest unconformably upon the cretaceous formation, from which it is readily distinguished. These marls formed the first deposition in the shallows of the Suessonian seas, and consequently present a very variable thickness. Commencing as alternations they gradually become entirely marly limestone, then true limestone and marl, which furnish the phosphate deposits. These beds of marls and limestones are variable in their thickness, and also in their richness in phosphoric acid, when we compare the different localities in which they occur, but the individual strata of the same locality are found to be remarkably constant in both respects. A thick bed of shell limestone overlies these phosphatized beds, and is particularly exposed in southern Tunis; but passing northward, it is replaced by nummulitic limestone, which is seen abundantly in central Tunis. In proportion as the limestone passes from a shelly nature and becomes nummulitic, the marl beds intercalated with the phosphatized limestone become granular, silicious and glauconitic, as is well seen at the Tarja railway depot near Soukahras, where the white nummulitic limestone attains a thickness of some 40 ft., and is interstratified with marls containing gasteropods. Below these limestones a well developed series of glauconitic sandstone is found, of which the upper horizon is a marly sandstone, very glauconitic, of from 4 to 5 meters in thickness, and carrying much phosphate with sharks' teeth and vertebræ. To the north of Beja, where the Lower Eocene covers a very considerable area, a still greater thickness of this particular stratum is developed.

It may be said generally that the eocene phosphates are found at the base of that system in unconformable contact with the cretaceous, and separated from the latter by a stratum of black sandy clay containing characteristic flints and saturated with common salt and gypsum. The phosphate is composed of alternations of marls with nodules and phosphatic limestones. The beds are overlaid with a shelly limestone in South Tunis, which passes into a thicker development of nummulitic limestone as we pass northward, the phosphate horizon becoming at the same time of a sandy and glauconitic nature.

These beds of phosphate are generally speaking more inclined in the south, and show less disturbance when overlaid by the nummulitic strata.

Character of the Phosphates.—As we have mentioned above, the phosphate of lime occurs in two district horizons, namely, in the marls, and in the limestones.

Nodular Phosphatic Marls.—Here the phosphate presents itself as nodules in the stratified marls which are generally gypsiferous; teeth and other fossil remains of fish and saurians are abundant. These marls are unctuous to the touch, and as first pointed out by M. Thomas* they often contain as much as 7% or 8% of organic matter of a bituminous nature, but as yet not well defined, being insoluble in carbon bisulphide and benzole. These stratified marls sometimes acquire a nodular nature; the accompanying stratifications of phosphatic nodules

*Phillipe Thomas, "Gisements de phosphate de chaux des hauts plateaux de la Tunisie," *Bulletin Soc. Geol. France*, 3d Series, Vol. XIX., p. 374, *et seq.*

are irregular, while the nodules themselves present various forms and dimensions, but are generally globular or striated and covered with a shining brown coating possessing a characteristic appearance.

The larger nodules bear a similarity to exaggerated coprolites, but are, however, poor in phosphoric acid, which is all contained in the outer shining incrustation, the interior being carbonate of lime. The smaller nodules of identical appearance, on the contrary, contain as much as 70% of tribasic phosphate of lime. It is evident that they are the result of a secondary action giving rise to this concentration of phosphoric acid around original nuclei by dissolution of carbonate of lime; the same phenomenon of origin is observable in the phosphates of Florida and South Carolina.

It is to be observed that these phosphate-bearing marls also exhibit small intercalated stringers of gypsum and nodules of celestin (sulphate of strontia), besides alkaline salts, which have an important bearing in studying the genesis of these deposits.

The marl-phosphates are of secondary importance as regards the Tunisian deposits; as yet they have only been exploited at one locality—Djebel Dekma, near Soukahras, and have not thus far yielded favorable results. There are, however, beds of this nature at Sidi-Ayret, near Teboursouk, which yield 60% of their bulk in nodules containing 70% of tribasic phosphate, and which, therefore, are capable of economic development as soon as the means of transportation exist. The phosphate-marls, however, are always found in conjunction with the phosphatic limestone, although the former are not generally included in the computation of the deposits.

2. *Phosphatic Limestones.*—These phosphates occur intercalated with the nodular marls referred to above. They are being extensively worked at Tebessa, the only center at present provided with railroad transportation. They form a somewhat friable and granular rock of a color varying from buff to greenish brown ; the quality most esteemed readily crumbles under the pressure of the fingers, and its specific gravity is not more than 2 when *in situ.* The material consists of an agglomeration of small grains of various forms cemented together by carbonate of lime ; certain grains are globular, possessing a lustrous brown incrustation, but earthy or fibrous when fractured, and are essentially a yellowish phosphate of lime. Other grains are of a grass-green color with scaly texture, or present minute masses with a corroded or scoriaceous appearance, suggestive of certain glauconites. There are also present small angular grains of hyalite (hydrated quartz), and it is worth observation that a chemical examination invariably discloses the presence of a notable proportion of gelatinous silica, or free hydrated silica. Finally, these phosphates invariably contain many organic remains, such as coprolites similar to those observed in the stratified marls, besides teeth and bones of fish and saurians more or less imperfect or worn. When the proportion of carbonate of lime dominates in these rocks they become grayish in color and then resemble the gray chalk (*craie tuffeau*) of Aply, Belgium. These beds of phosphatic limestone are very variable, both as regards their relative position and their respective thickness, but on the other hand show a great constancy of character in the individual deposits. Their thickness may vary from a few inches to 9 and 10 ft. or more, and maintain such thickness

without interruption over an extent of 30 miles, as occurs in the western mountain chain of Gafsa.

The conditions described above suggest the manner of the formation of these deposits. The dissolving out of the greater part of the carbonate of lime originally existing in the phosphatic limestone has resulted in a corresponding augmentation of the proportion of the phosphate of lime remaining insoluble and leaving the rock porous and friable ; simultaneously a deposition of previously dissolved tribasic phosphate of lime took place on the surface of the granules, thereby giving them their lustrous character. A similar phenomenon of enrichment is observable in the fossil bones occurring in the limestone beds, since their analysis shows them to possess a larger proportion of phosphoric acid than is due to their original constitution as bones. We observe here the same general principles of phosphate formation as have operated in all other eocene deposits, Florida for example.

The deposits of southern Tunis include Gafsa, Tamerza, Djebel, Jellabia and others ; passing northward we have the deposits of central Tunis, Tebessa, Galaat-es-Snam, Thala, Nasser-Allah ; and lastly coming to northern Tunis we find deposits in the neighborhood of Soukahras, those of Beja, Sidi-Ayet, etc.

Phosphates of Southern Tunis.—Between Gafsa and Tamerza, and extending in an east and west direction, there is a chain of mountains formed by an upheaval of upper cretaceous rocks. This anticlinal has considerably disturbed the eocene strata, giving them an almost vertical inclination. The strata containing phosphates have been the most appreciably affected by atmospheric agencies, giving rise to troughs of erosion in the surface configuration. The phosphate-bearing beds on the south of the anticline present a series of strata of greenish-brown color, intercalated with stratified brown clays. A perfect regularity in the succession of the statification may be observed over a distance of some 40 miles. These are overlaid by several strongly developed beds of shell limestone, which extend southward, passing into a layer of white gypsum in contact with miocene rocks. This is shown by Fig 1, Plate II., which represents a north and south section on the line of the outcrops.

The regularity of succession and development, as seen by this section to obtain in the south side, gives place to much disturbance on the north anticlinal of the upheaval of the cretaceous rocks ; here we find a series of undefined disturbances. Generally speaking, it may be said that the eocene rocks have been folded, and subsequently eroded by subaërial influences, but on the whole they still maintain the order of succession as exhibited in the general sections, Figs. 2 and 3, Plate II.

At Djebel Tarfai and Djebel Methaoui the cretaceous rocks have but slightly upheaved the tertiary strata, which have in consequence only little elevation and are partly hidden. At other points, on the other hand, the eocene rocks form a series of foldings, traversed by faults which result in a confusion among themselves and with the cretaceous appearing in their midst. Nevertheless the shell limestone maintains a constant and relative position with the phosphate beds, identical with that existing on the south anticlinal of the mountain chain.

The thickness of the phosphated horizon is approximately 250 ft., a maximum of over 320 ft. being attained in the central portion, and a gradual decrease

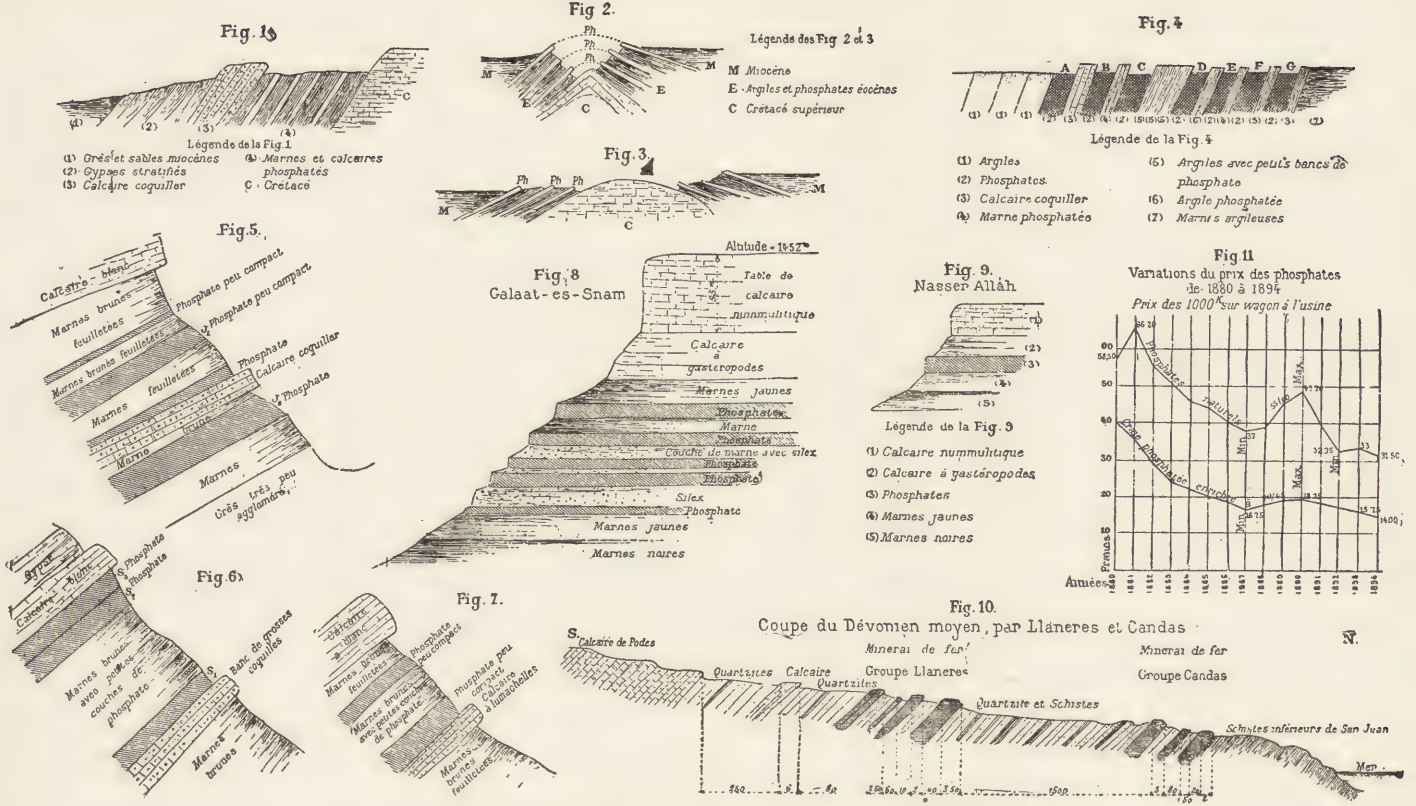


PLATE II.—GEOLOGICAL SECTIONS OF THE PHOSPHATE DEPOSITS.

taking place toward the east. Returning to the south are deposits which comprise the more important zone; a general section of them is exhibited at Khanguet-Seldja (Fig. 4, Plate II.). There are seven distinct beds, possessing a total thickness of 32 ft.

Extending from Djebel Stah to Djebel Zeitoun, the outcroppings are hidden by 3 to 6 ft. of broken overburden, but the beds are still traceable in the series of valleys which descend to the plain, and exhibit a remarkable constancy in their thickness of 32 ft. The bed marked *A* is the most irregular in thickness, but this even falls below 5 ft. and sometimes exceeds 9 ft. The beds are exposed continuously at the surface between Gafsa and Tamerza for a distance of 37 miles; they are easy of extraction over two-thirds of that extent without any other preparatory work than a small amount of surface stripping. The phosphate of these deposits is gray and granular; the beds themselves are homogeneous in structure. In one of the small secondary beddings, sharks' teeth, and coprolites of the size of a walnut are found; the same is observed in the marls which separate the phosphate rock, but these products are not taken into account in the estimation of the cubic contents.

Finally, it is to be noted that the shell limestone also contains an appreciable quantity of phosphoric acid, and some samples have given as much as 37% of tribasic phosphate of lime.

The phosphates of Gafsa are rich and regular in their yield. They have been thoroughly investigated by M. Mercier with a view to the industrial utilization of the deposits, and also by the Department of Mines of the Regency. The following is a complete analysis of an average sample from Djebel Seldja: Silica, 6.90%; oxides of iron and alumina, 2.50%; lime, 10.70%; carbonic acid, 8.10%; sulphuric acid, 5.40%; tribasic phosphate of lime, 61.89% (=28.35% P_2O_5); loss at 100° C., 4.51%—total, 100%.

The results of investigations are strictly concordant, and indicate that a yield of 55% to 60% can be relied upon for the Gafsa phosphates without either selection or washing, and that a product averaging more than 60% can be secured by cleaning and washing the raw phosphates. This is, however, less than what is being actually attained by simple selection at Tebessa.

The measurement of the phosphate rocks in sight, and attainable by open quarry work to a depth of 32 ft. from the south outcrops, gives 5,000,000 tons of rich phosphate rock, without taking into account the phosphatic marls or the beds yielding less than 52% tribasic phosphate. The only question to be considered in working these deposits is the construction of a railroad from Gafsa to Sfax, a distance of about 160 miles.

The Djebel Jellabia et Djebel deposits, situated about 18 miles south of the Oued-Seldja, are but imperfectly known. The bedding is roughly similar to that of the Oued-Seldja, as may be seen by comparing Figs. 5, 6 and 7 in Plate II.

Two beds, J_1 and J_2 (Fig. 5), have given, respectively, 52.17% and 50.23% tribasic phosphate in the raw product. The deposit is traversed by many faults, and no cubic measurements have been made. The strata of the cretaceous formation at Djebel Sehib are nearly horizontal. The eocene rocks south from Djebel are nearly vertical. The deposit presents a character analagous to that of

the south side of Khanguet Seldja. The section given in Fig. 6 shows the relation of the phosphate beds to the white limestone and the shell limestone; these two characteristic horizons are the constant guides in tracing these deposits.

Samples taken from the strata S_1, S_2 and S_3 (Fig. 6) gave, respectively, 59.99%, 43.80% and 20.93% tribasic phosphate, which shows that the first-named bed is an important one, while the second one, which may be enriched by washing, has a certain additional value.

Northward from Djebel Sehib the tertiary formation appears at intervals, the phosphate-bearing beds overlying the shell limestone being sometimes replaced by stratified marls. Below the shell rock is a blackish marl, some 60 ft. in thickness, possessing marked stratification, and enclosing a bed of phosphate of about 2½ ft., of which the samples have yielded 57% upon the unwashed material. This marl bed reposes immediately upon the cretaceous rocks.

Fig. 7, Plate II., represents another section of the same region lying north of Djebel Sehib; it shows how the phosphate beds are more strongly developed when contiguous to the shell limestone. It may be inferred that these strata show greater variation in their constitution and sequence than do those of Gafsa.

In the locality south of Djebel Sehib we may calculate on a thickness of almost 10 ft. of rich phosphate rock, of which the beds are continuous over a distance of nearly 50 miles. Taking 25 ft. depth, workable by open quarrying, we obtain some 400,000 tons available in this locality. Regarding the deposits situated north of Djebel, they require further investigation to permit of computing their probable quantity; but the richness of the rock in phosphoric acid is already indicated.

2. *Phosphates of Central Tunis and of the Algerian Frontier.*—In the deposits in the Tebessa region preliminary work was commenced in 1892 and regular production dates from the fall of 1894. The all-important question of furnishing transportation by the construction of a railroad from Tebessa to Soukahras has not long been settled. As all the minerals from Tebessa for export pass through Bona, the exportation of phosphate from that port since 1893 furnishes the output of the mineral coming from Tebessa; there was no other region operated during 1893–1894. In 1893 the shipments of phosphates from the port of Bona amounted to 4465 tons; for the nine months of 1894 ending with September they were 29,008 tons, of which 28,308 tons went to foreign ports and 700 tons to French ports.

Three companies are at present working the Tebessa deposits—the Crookston Company, the Jacobsen Company, and a French company. The Crookston Company is mining on the Plateau du Dyr. The workings are underground, on the phosphate beds situated below the nummulitic limestone. The phosphate is separated into several strata varying in thickness from 6 to 9 ft. Two qualities of marketable phosphate are made by selection; the poorer containing from 58% to 63%, and the richer from 63% to 69% tribasic phosphate, and it is upon the basis of an average between these two limits upon which the contracts for delivery are made.

The constitution of these products is excellent for the manufacture of superphosphates, furnishing a finished product of 14% to 15% phosphoric acid

without other addition; the superphosphate remains dry and granular, is readily powdered, does not agglomerate in the sacks, and does not retrograde or revert. These good qualities secure a ready sale for the Tunisian and Algerian phosphates, more particularly in England; about 60% of the actual output from Tebessa has gone to English ports.

The Dyr deposits are connected with the railroad from Tebessa to Soukahras by a wire rope line, operated since July, 1894; before that time the transportation from the mines to the railroad was effected by camels.

The Crookston Company now turns out about 200 tons per day; this was the first organization to commence work, and the first also to attain a regular output.

The Jacobsen Company—otherwise known as the Constantine Phosphate Company—is working upon the extension of the Plateau of Dyr, and its products are identical with those of the Crookston Company; but the beds have a greater thickness, attaining as much as 19 ft. In some places the superincumbent nummulitic limestone is wanting, so that the phosphate is extracted by open workings. The company has been at considerable expense in connecting these mines with Tebessa by a branch railroad 18 miles in length, but with this completed it will be in a position in 1895 to export a quantity of phosphate at least equal to that of the Crookston Company, and under very favorable economic conditions.

The only French company in operation at Tebessa is managed by Colonel Corps in connection with the firm of Hébré & Girault of Paris. Their mines are much nearer the railroad than those of the other two companies, being within 5 miles of the Bona-Guelma line. These three companies taken together will be in a position to produce in 1895 at the rate of 500 tons per day, or 150,000 tons of high-grade phosphate for the year.

The following table will give the cost of producing a ton of phosphate in the case of the mines which are already in communication with the railroads.

Mining	3.00f.	3.00f.
Sorting and drying	1.00	1.00
Transportation to railroad	0.50	1.50
Rail freight to Bona	9.00	9.00
Loading on ship	0.50	0.50
Freight to Mediterranean ports	6.00	....
Freight to other European ports	....	9.00
General expenses, wear and tear, etc.	3.00	3.00
Commission on sales	1.80	2.00
Total	24.80f.	29.00f.

This will give a cost of, say from $4.90 to $5.80 per ton, leaving a margin of from $1.60 to $2 per ton on the present market price of 60% rock with which to pay royalties, interest on capital, etc. The figures of cost given in the table above show that there would be no profit in exporting rock carrying less than 55% at the present market value, which is 0.60 to 0.625f. per unit for 60% phosphate. It is probable, however, that rock running less than 55% might be profitably treated near the mines. This depends essentially upon the cost of making sulphuric acid at Bona.

It must be remembered, however, that the development of the Tebessa deposits

is limited by the shipping facilities. At present the capacity of the railroad is not great. It is a narrow-gauge line, with but small equipment of rolling stock. This could, however, easily be increased; but many improvements must be made at the port of Bona to make shipments there easy and economical. The present cost of transhipping is very high. Under all the circumstances it will probably be two or three years before the Tebessa mines can be counted upon as large shippers.

Continuing northward we find the Dyr formation still better defined at the celebrated mountain of Guelaat-es-Snam. M. Thomas says of the phosphate deposits and of this mountain chain that it is an immense mass of limestone (Fig. 8, Plate II.), of rectangular form, with vertical sides 300 ft. deep, surmounting a quadrangular pyramid, of which the base reposes on the cretaceous rocks. Narrow steps artificially cut in the north escarpment of this gigantic table gives access to the surface platform, in the center of which are the ruins of a "zöonie," formed of ancient monuments. This block of semi-crystalline and hard red limestone is only rivaled in its abundance of nummulites by the famous Djebel Mokattam of Cairo, which geologists have so often discussed. The remains of foraminifera are so plentiful that many dozen may be counted in the section of a few square centimeters of any part of the rock. It may be affirmed without any exaggeration that these organisms form 90% of the total mass. The rock is very homogeneous in its texture, but little angular grains of quartz, possessing sometimes a red tint, and a few gray nodules containing traces of phosphoric acid, are discernible in the mass, in which are found a few fragments of fish-teeth. Near the upper horizon of this table the casts of oyster-shells are frequently intermixed with the nummulites. The nummulites of Guelaat-es-Snam appear to resemble those of Dir-el-Kef, which, according to M. Ficheur and M. Pomel, belong to the same groups as those found at Dekma.

Recently it has been recognized that the marls which are found intercalated with the phosphate beds possess more importance than was at first imagined, and an English company, after some preliminary explorations, has proved the existence of certain strata carrying as much as 62.22% of tribasic phosphate, and will acquire a concession. The working will require the construction of 50 miles of branch railroad to connect it with the Tebessa-Soukahras line.

These phosphate beds were first met with at Guelaat-es-Snam (Fig. 8, Plate II.), and later at Kef-Rabeba, Kef-Kackiche, Ain Taga, Zoubia, etc. The nummulitic limestone at Guelaat-es-Snam does not immediately overlie the alternating beds of marl and phosphatic limestone; but a certain thickness of white limestone containing gasteropods separates these horizons; this last named is a transition bed between the true nummulitic stratum of North Tunis and that of the Gafsa region of a deep sea type and characterized as being of the upper limestone. The latest investigations have shown the total thickness of the Guelaat-es-Snam phosphate beds to be about 32 ft.

In the district of Haydra we find exactly the same geological occurrences at Kef-Rabeba and Kef-Kackiche. Descending the Haydra Hill on the southeast side we first have the Guelaat-es-Djerda deposit near Haydra. The phosphate beds here have still a thickness of some 32 ft., but their superficial extent is much less than that of Guelaat-es-Snam. The plain of Djebel Kouif extends

between Haydra and the Tebessa deposits, and is crossed by the frontier; this plain is covered by the debris of nummulitic rocks, and the phosphate beds have been partially eroded. The known thickness does not exceed from 9 to 13 ft.; otherwise their order of sequence is similar to the other parts of the formation.

In the district of Thala the phosphate formation continues on to the east, but the beds are appreciably modified, and are partly overlain by miocene rocks. The shell beds are slightly phosphatized, but the true phosphate beds give place to phosphatic marls. These deposits have a very large area, but their yield in phosphoric acid is low. The preliminary researches so far carried on in these localities have been of little importance. The same may be said of the deposits to the east of Thala, at Djebel Reukaba and at Sid-Ali-ben-Oum-el-Zine. They are described as black and gray phosphates possessing a thickness of 32 ft., which are probably the continuation of the Haydra beds. If this be so, the Thala deposits may become much more important than they have been considered up to the present time. The whole of this central region needs further exploration, but the undertaking does not afford immediate interest, seeing that there are so many other localities better known and easier of access which ought to be first turned to account.

In the district of Nasser Allah the Thala deposits unite with those of Nasser Allah to the southwest of Kairouan, forming the eastern boundary of the central Tunis deposits. The Kairouan phosphates have been carefully studied, thanks to their proximity to the seacoast, and especially as the projected railroad from Sousa to Kairouan, which is to replace the existing tramway, is included in the system of Tunisian roads which are to be constructed very shortly. Investigations have shown that the phosphates of this district do not average more than 45% in the raw state, but they may be enriched by washing.

Regarding geological conditions, the nummulitic limestone is found at the surface, and overlays the white limestone with gasteropods, as in all the central region; then follows the phosphate horizon, and below these yellow and black marls (Fig. 9, Plate II.). The outcrops having a general strike of north and south cover a considerable area. They form two parallel lines of elevation from Ain Merota à Oued-el-Feka, extending for nearly 18 miles. The eastern elevation commands the sea at a distance of about 60 miles, that of the west descends to the valley of Bin-el-Djebel, which separates it from Djebel Sidi-bou-Gobrine. Coprolites are very abundant in places, and they furnish a rich material after washing. A series of analyses gives from 26.5% to 42% of tribasic phosphate.

In the northern provinces the deposits at Djebel Dekma, in the district of Soukahras, were the first phosphates worked in Algeria, on account of the ease of transportation, since they are close to the Bona-Guelma Railroad. The working was commenced upon the marly beds, which yielded a product of 50% to 55% only after a costly washing. The beds of granular sand and friable phosphates of lime which characterize the richest deposits were not found here. Mining and grinding were, however, carried on up to the time of the fall in market prices which followed the discovery of the Florida deposits. Exploration, however, was not given up, and M. Wetterle, the original discoverer of these deposits, has recognized the existence of a strata of phosphates directly overlying the limestone and below the marl beds; this yielded from 50% to 65% of tribasic phos-

phates. This is a fact of some importance, because if it is confirmed it will furnish a new horizon for explorations in the localities where the limestone is found. Prospecting is difficult in this district, however, owing to the fact that the greater proportion of the surface is overlaid by miocene sandstones and clays and there are no outcrops in the valleys similar to those found at Tebessa. At Ain Seymour there are outcrops of the characteristics known, but the phosphates contain a large proportion of silica.

Below the eocene phosphates of this district there are other beds belonging to the deposits of the miocene period, and these were discovered in several localities before the recognition of an eocene phosphate. So far, however, they have not been found sufficiently rich for profitable working.

The Kef deposits are of this character, belonging rather to the Tebessa system than to the northern plateau of nummulitic rocks known as Dyr-el-Kef, which has an elevation of about 2700 ft. The beds as far as tested are about 19 ft. thick, and the average yield does not appear to be over 35% to 40%, but further explanation is needed to fix the economic value of the beds. Other deposits have been tested along the coast of the Medjerdah at several points, but they are too far removed from transportation to be of immediate or present value.

In the Beja district the eocene formation is strongly developed, but instead of stratified marl and limestone there is a succession of clay, red sandstone, sometimes carrying phosphates, and of yellow sandstone with phosphorized fossils. These sandstones underlie the eocene limestone as is shown in Fig. 4, Plate II.

The deposits of Sidi-Ayet are continued in the valley of Oued-Siliana, about 34 miles from the Tunis-Ghardimaon Railroad; the proposed branch to the Fahi plain will have its terminus not far from these deposits. Some outcrops from these beds are on the right bank of Oued-Siliana, take a north and south direction, and dipping to the west further overlay great marls and alternate with beds of limestone, yellow marl and clay. The beds comprise four groups. The first of these explored by M. Mercier is only of secondary importance. Trenches extending nearly 1000 ft. have exposed two beds of clayey phosphates dipping at an average of 35°, and varying in thickness from 1½ to 2½ ft. Above these beds there is a small stratum from 8 to 10 in. thick of phosphoric sand. Samples from two beds gave an average of 7.45% phosphates.

The second group at Ragoubet-am-Bey is separated from the first by yellowish marls and comprises also several beds, each about 1½ ft. thick, with two or three smaller ones of from 8 to 12 in. thickness. These alternate with marly limestone. The average yield of these beds is low in phosphoric acid, the analysis not showing over 30%. In both of these groups, however, the explorations so far have only been superficial.

The third group, found at Oued-Merire, shows beds carrying a large quantity of rich phosphatic nodules and coprolites, and is the most important yet located. The beds are of sand alternateing with marl and clay and the nodules are obtained as far as the beds have been uncovered. The thickness is variable, the limits being 1½ to 2¾ ft. Analysis gave an average varying from 42% to 63% tribasic phosphates, the part not carrying nodules assaying 10.6%. The nodules analyzed by themselves gave for the white 65.5% tribasic phosphates, and for the black 60% to 70%. As far as the beds have been examined it may be said that the

nodules comprise about three-fifths of the whole and could readily be separated from the mass.

In the fourth group, at Krechem-Ahmar, a bed is found between two strata of blackish limestone; it consists in fact of two small beds having a total thickness of about 3 ft., and samples given yielded on an average from 25% to 26% of tribasic phosphates.

Of these four groups of phosphate deposits described, the third is the only one which is likely to have much commercial importance, taking into consideration the yield in phosphoric acid and the ease with which it may be separated from the friable matrix.

Apatites.—Before closing this description of the Tunisian phosphates it remains to mention the deposits of apatite, or more correctly, the concretionary phosphorite which have been found in the Jurassic and lower cretaceous formations in the neighborhood of the city of Tunis. Analyses of samples from Djebel Zaghouan contain 55.80%, 68.81%, 70.87%, 76.73%, 78.13% and 80.35%. A sample from Djebel Ressas, taken in January, 1894, gave 60%.

The Veille-Montagne Company is exploiting a vein of apatite at Zaghouan, of which the above analyses represent the yield.

This exceptional quality of phosphate is found in the same formation and under similar conditions to the zinc calamine with which it is often confounded. The same occurrence exists at Djebel Ressas, where the phosphorite is found in pockets and stringers in proximity with the pockets of calamine. These secondary and local deposits of concretionary phosphates can furnish only limited quantities for a short time, but it appeared to be of interest to mention their association with calamine; they are not limited to the two localities mentioned above, but have been also found at Djebel Dekma, near Soukahras, where a concretionary and banded calamine is found as an incrustation upon limestone, alternating with concretionary phosphorite of identical appearance, and it is only by a chemical analysis that they may be distinguished one from the other.

The mining regulations for working phosphates in Algeria and Tunis are not yet established in a regular manner, whence arise many difficulties, delays and uncertainties, which cause serious injury to private enterprise. These difficulties in Algeria arose from two chief causes: in the first place, from the still embryonic organization of the individual right of property, which prevents any security in transactions between natives and Europeans in the case of concession of lands where documentary titles do not exist, and this is the case with almost all of the lands upon which the phosphate deposits are situated; in the next place, the lands owned by the native inhabitants, and termed "*terrains melks,*" only form a small fraction of the territory; speaking generally, the deposits are situated either upon communal lands, upon lands of the State, or upon forest lands.

The practice of sale by public adjudication is unjust to the discoverers of the deposits, and to those who have risked the necessary expense of proving their value. It must therefore discourage capital for these ends, to the detriment of the country.

Regarding the deposits upon lands belonging to the State, Tunis is not much further advanced than Algeria in the matter of a definite concession. It is a

fact, however, that up to the present time the regular exploitation of a phosphate mine has not been commenced in Tunis, and the question of future work depends in a great measure upon the decision as to the construction of a railroad to connect Gafsa and Sfax. Nevertheless, the applications for permits for prospecting upon the lands of the state in Tunis are in future to be treated in the same way as applications for mining rights.

When the applicant demands it, and if the exploratory work is considered to be satisfactory, permission may be obtained to sell, and this permission may be renewed similarly to the permission for exploring.

It will be readily understood from the description given of the principal deposits of phosphate in Tunis, and of the Algerian frontier, that their utilization and development is intimately connected with the extension of the system of railroads. The Tebessa deposits could not have been exploited but for the existence of the line from Tebessa to Soukahras, and this was constructed moreover with other ends in view.

The railroad branch of 75 miles operated by the Bona-Guelma Company is not of the same gauge as the remainder of the system of that company, and it is necessary, therefore, to transfer freight at Soukahras. This transfer is now effected by manual labor, and even if this be improved upon there will always exist a serious obstacle to rapid and cheap transport. It should be taken in account, however, that the Bona-Guelma Company, to encourage the phosphate industry, established a rate which appears to be the lowest tariff that could be expected, and, considering the necessary transhipment of the freight at the Soukahras depot and the nature of the road-bed through a rough country, this rate may be considered to be very near the actual cost.

These considerations have evidently guided the Tunisian government in establishing the project for railroad service which it proposes to carry out with the concurrence of the French Chambers.

Following explorations which have shown the undoubted existence of very extensive quantities of rich phosphate surface deposits in the region of Gafsa, negotiations were commenced for the construction of a railroad from Gafsa to Sfax, guaranteed by the government of the Bey, and consequently by that of France, the constructing and operating company to receive the concession of the phosphate deposits. This project did not succeed. According to the opinion held by the administration, those deposits which have a real value should in principle be the sole guarantee of the revenue of the railroad. The administration would even demand the advance payment by the concessionaire of a sum of money equal to the construction capital required for this line, to be built by the Tunis government under the same conditions as the other projected roads, and require it to be incorporated into the general system. The government would demand from the concessionaire the payment of a tax or royalty per ton in addition to the above-mentioned sum.

Considering the present situation of phosphate affairs it would appear to be difficult to find the large amount of capital necessary for constructing a railroad of the importance of that from Gafsa to Sfax, and one that would have to depend solely upon the transport of phosphate, a mineral which is so subject to fluctuations of market value, for the revenue of the road. On the other hand it is

not desirable for the general good that such deposits as those of Gafsa, easy of extraction and requiring small outlay to render them productive, should pass into the control of a monopoly. This would be offering a sure gain to speculators in a commodity which lends itself to this operation.

To conclude this brief study of the phosphate deposits of Tunis and Algeria something should be added concerning the strictly Algerian deposits.

The eocene deposits of Tunis and of Tebessa certainly continue through the south of Algeria. On the accompanying map (Plate I.) the localities in which they have been observed to have a certain importance are traced. The more successful enterprises may be looked for near the termination of the high plateaus and in the neighborhood of the desert region of the (*shotts*) lakes—that is to say where the topographical and geological conditions are similar to those existing at Gafsa and Tamerza.

M. Blayac* has referred to beds of phosphate existing in the eocene near Sétif and at Bordj-bou-Arreridj, where the formation acquires an extensive development. Others are known to exist near Guelma at Oued Zenati, also further south on the spurs of the Aures range, toward the lakes region, and in the neighborhood of Biskra.

The extraction of phosphates from these deposits in Tunis and upon the Algerian frontier have attracted attention, and in proportion as the special topography of the lower eocene becomes better known so will the discoveries of phosphate in this horizon in Algeria increase. But besides the eocene deposits the miocene phosphates have been and are still worked in the Province of Oran, although upon a small scale only. Although these deposits are very pure and of a high grade, they are far from possessing the value of those of the eocene period. They are phosphorites incrusting the fissures and caverns which constitute the character of these strata. Unless more favorable discoveries are made these deposits are limited in quantity, and cannot support a considerable outlay for extraction plant and expenses with a yield uncertain in quantity.

In the Province of Oran the miocene formation obtains a considerable development in the Cheliff valley. The middle beds (Helvetian) are represented by a limestone containing fossils of algæ, numerous bryozoa, foraminifera, etc. Its thickness is very variable, but attains more than 320 ft. over a large area. These limestones are appreciably phosphatized.

The formation contains numerous cavities and natural caverns which result from the marked stratification of the limestone. The contents of these caverns consist of deposits which always occur in the following order : A bed of concretionary and stalagmitic phosphate of lime, of white or light yellow color, rich in phosphate and of variable thickness, forms the base, directly overlies the limestone, and is generally conformable to its dip. Above this comes phosphated earth, intermixed with oxide of iron, sand and clay. The earth is overlaid by clay, but sometimes the upper part of the cavern is empty. The cavern usually communicates with the surface by a chimney filled with vegetable mould, making its existence noticeable by a corresponding depression with earthy soil, while the adjoining surface is bare limestone. These caverns communicate with each other

* *Annales des Mines*, Series 9, Vol. VI., p. 331.

by a system of irregular passages which have served for the circulation of the waters depositing the phosphate. These passages, termed water-holes by the miners, furnish the guide for tracing out new caverns, and present the same typical concretionary phosphate at the lower part and phosphatized earth in the upper stratum.

M. Bourbon found a sample of compact phosphate in the concretionary phosphate of one of these caverns; this sample of earthy and friable exterior contained two fossils in the center, namely, *Nummulites planulata* and *Pecten plebeius*, both of which are characteristic of the Suessonian. The proportion of phosphoric acid in the limestone which forms the wall rock of these caverns is worthy of note. An analysis made by the School of Mines, Paris, upon a sample coming from the vertical walls of the Leghar cavern gave: Total phosphoric acid, 4.25%; lime, 80.60%; oxide of iron, 6.30%. This corresponds to 9.87% tribasic phosphate of lime.

The nuclei of the same limestone forming the center of concretion and deposition of the nodules of banded compact phosphate contained in the strata of the cavern only gave: Total phosphoric acid, 0.80%; limestone, 90.20%; oxide of iron, 2.30%. This would appear to show that this limestone had lost in phosphoric acid by the action of the waters of sedimentation.

The stalagmitic deposits of phosphorite are frequently accompanied by layers of aragonite more or less thick, alternating with the phosphate. So far as the present explorations of these deposits show, the phosphate caverns occur along a line which coincides with the direction of an anticlinal of the Melobesian limestone.

In spite of the indications inclining to attribute these phosphates to a vein formation of direct hydrothermal action, similar to the pockets of silex clay in the "grossier" limestone, as held by M. de Lapparent, the opinion of geologists who have studied these deposits is that the origin of these phosphates is explained by the denudation, the dissolution and transport of the phosphate contained in phosphated stata of the Miocene by the agency of waters charged with carbonic acid, and possessing thereby the power of holding considerable quantities of tribasic phosphate of lime in solution. The phosphate would be subsequently deposited by contact with the Melobesian limestone. In short, we have here the two theories "*per ascensum*" and "*per descensum*," which oppose each other anew, concerning the deposits of the plains of Cheliff. Each may furnish an explanation sufficiently in accordance with the facts so far observed.

The work of extraction is chiefly centered in the neighborhood of Inkermann, on the railroad from Algiers to Oran; but other accumulations of this nature are known at many other points, and far separated from each other, although the conditions of the deposits are identical. The principal places are Inkermann, Merdja, Charon, Relizane, and Djidiouia, near Relizane.

Up to the present time only the concretionary phosphate is utilized. In order to enrich the phosphated earths to a marketable point it would be necessary to treat them by washing, and this is now rendered impracticable by the local want of water and the low market value. In addition to this, it is only very rich phosphates which could bear the primitive and costly transportation methods now in use.

FLUORSPAR.

No change of importance is to be noted in this industry during 1894. The production is still confined to the deposits in Hardin County, Illinois, which have supplied the market for a number of years past. The mineral has been found in Arizona, New Mexico, Colorado, California and New York, and there are deposits of considerable importance along the Cumberland River in Livingston and Crittenden Counties in Kentucky. The latter have been worked to a small extent, but none of the Western deposits have been even developed, and the Kentucky output has been very small so far. The extent of the Illinois deposits and the ease and cheapness with which they can be worked have enabled them to command the market entirely up to the present time.

The following table gives the production for the five years, 1890 to 1894 inclusive; the statistics for the years previous to 1890 will be found in The Mineral Industry, Vols. I. and II. It will be seen that the output in 1894 showed a small decrease from that of 1893, although it was about the same as in 1892. The prices show a small increase.

PRODUCTION OF FLUORSPAR IN THE UNITED STATES.

(In tons of 2000 lbs.)

Year.	Quantity.	Value Per Ton.	Value.	Year.	Quantity.	Value Per Ton.	Value.	Year.	Quantity.	Value Per Ton.	Value.
1889....	9,500	$4.83	$45,835	1891....	6,320	$6.00	$38,000	1893...	9,700	$6.50	$63,000
1890....	8,250	6.70	55,328	1892....	9,000	6.00	54,000	1894...	9,000	7.10	64,000

The best quality of spar is ground and shipped in barrels. Its most important use is in the manufacture of glass, for which the larger part of the production is taken. It is also the basis for the manufacture of hydrofluoric acid, and has some minor uses which do not require, however, a large quantity. The second-class spar, which contains some galena, limestone and other impurities, is not ground. This quality is used chiefly as a flux in foundry cupolas, and its employment for that purpose is gradually increasing where it can be obtained without too great a cost for freight; it finds no place for this purpose, however, where limestone of good quality can be had cheaply. The galena which is found to a considerable extent in connection with the fluorspar is separated by crushing and jigging and sold to the smelters.

GOLD AND SILVER.

THE year 1894 saw a still further expansion of the output of gold and a slight reduction in the world's production of silver, though in the United States the output of the white metal declined about 18%. The working out of old bonanzas here and in other countries progresses, and few new silver mines are being opened, so that the output of the metal will certainly decline during some years to come, whatever its commercial value may be, and this decline will be very large if the value of the metal remains low. The output of gold, on the other hand, is rapidly increasing, new bonanzas are being opened, and, until checked by the diversion of capital now so lavishly, and frequently so unwisely, invested in it, this increase will continue.

The accompanying table gives the production of gold and silver in the United States in 1893 and 1894, the amount produced in the several States, and the amount of foreign gold and silver refined here each year.

PRODUCTION OF GOLD AND SILVER IN THE UNITED STATES BY STATES.

State or Territory.	1893.			1894.		
	Gold.		Silver.	Gold.		Silver.
	Fine Ounces.	Value.	Fine Ounces.	Fine Ounces.	Value.	Fine Ounces.
Alaska	48,863	$1,010,100	9,600	53,868	$1,113,550	22,261
Arizona	57,286	1,184,200	2,985,700	96,313	1,990,966	1,539,453
California	584,370	12,080,000	470,100	656,468	13,570,397	717,368
Colorado	364,119	7,527,000	26,000,000	61,969	9,549,731	23,236,025
Georgia	4,702	97,200	500	4,738	97,736	325
Idaho	79,669	1,646,900	3,910,700	100,682	2,081,281	3,288,548
Michigan	2,032	42,000	43,500	2,150	44,444	35,122
Montana	172,989	3,576,000	17,000,000	176,637	3,651,410	12,820,081
Nevada	46,367	958,500	1,700,000	55,042	1,137,819	1,035,151
New Mexico	44,171	913,100	458,400	27,465	567,751	632,183
North Carolina	2,593	53,600	13,400	2,254	46,594	352
Oregon	79,592	1,645,300	11,800	68,792	1,422,056	26,171
South Carolina	5,998	124,000	500	4,733	97,839	305
South Dakota	193,809	4,006,400	140,400	159,594	3,299,100	58,973
Texas	.....	.....	349,400	.....	.....	429,314
Utah	41,283	853,600	7,252,600	41,991	868,031	5,891,901
Washington	10,744	222,100	152,700	9,438	195,100	113,160
Other States	726	15,000	700	1,495	30,903	182
Total domestic product	1,739,323	$35,955,000	60,500,000	1,923,619	$39,764,708	49,846,875
Foreign product	103,878	.....	23,221,811	117,765	2,434,202	20,342,711
Total refined or exported	1,843,201	.....	83,721,811	2,041,384	$42,198,910	70,189,586

These statistics of gold and silver production were collected for THE MINERAL INDUSTRY, but we are indebted to the Director of the United States Mint for the approximate distribution by States.
Gold, $20.67 per oz.; silver, commercial value in 1893, 78.2c. per oz., and in 1894, 63c. per oz.

The production of gold in 1894 amounted to 1,923,619 fine ounces, or $39,764,708, which was greater than in any year since 1878. An increase was shown in the returns of nearly every State and Territory, but was greatest in Arizona, California and Colorado.

The accompanying diagram, and the table on page 6 of the "Introduction," show the monthly production of gold and silver in the United States and the commercial value of the same. The importance of accumulating data for the intelligent study of this output, and the effect of changing conditions upon output of gold and silver, has led us to the collection of these monthly figures, which the producers have, with the utmost courtesy, placed at our disposal. The sudden closing of the India mints to free coinage in 1893 affected the price, and, with it, the output of silver in this country, more deeply than the diagram shows, for the production of fine silver continued by working up the stocks of ore and bullion at the refineries long after many of the mines had closed. So also the effect of the repeal of the Silver Purchase Act was not so noticeable in the output as might have been expected. The gradual exhaustion of stocks and of bonanza mines, and the cessation of prospecting for silver mines, will in the next few years show more and more clearly the effect of the closing of the world's coinage market to silver.

The United States contains large gold placers in California (where, however, the State laws interfere with its production), in Idaho, Montana, and to a certain extent in Arizona, Colorado and some other States. The gold-bearing ores must, however, be always the chief sources of the metal in this country, and the great improvements being made in mining and metallurgical methods and processes are steadily increasing the amount of workable gold ores by lessening the cost of winning the metal.

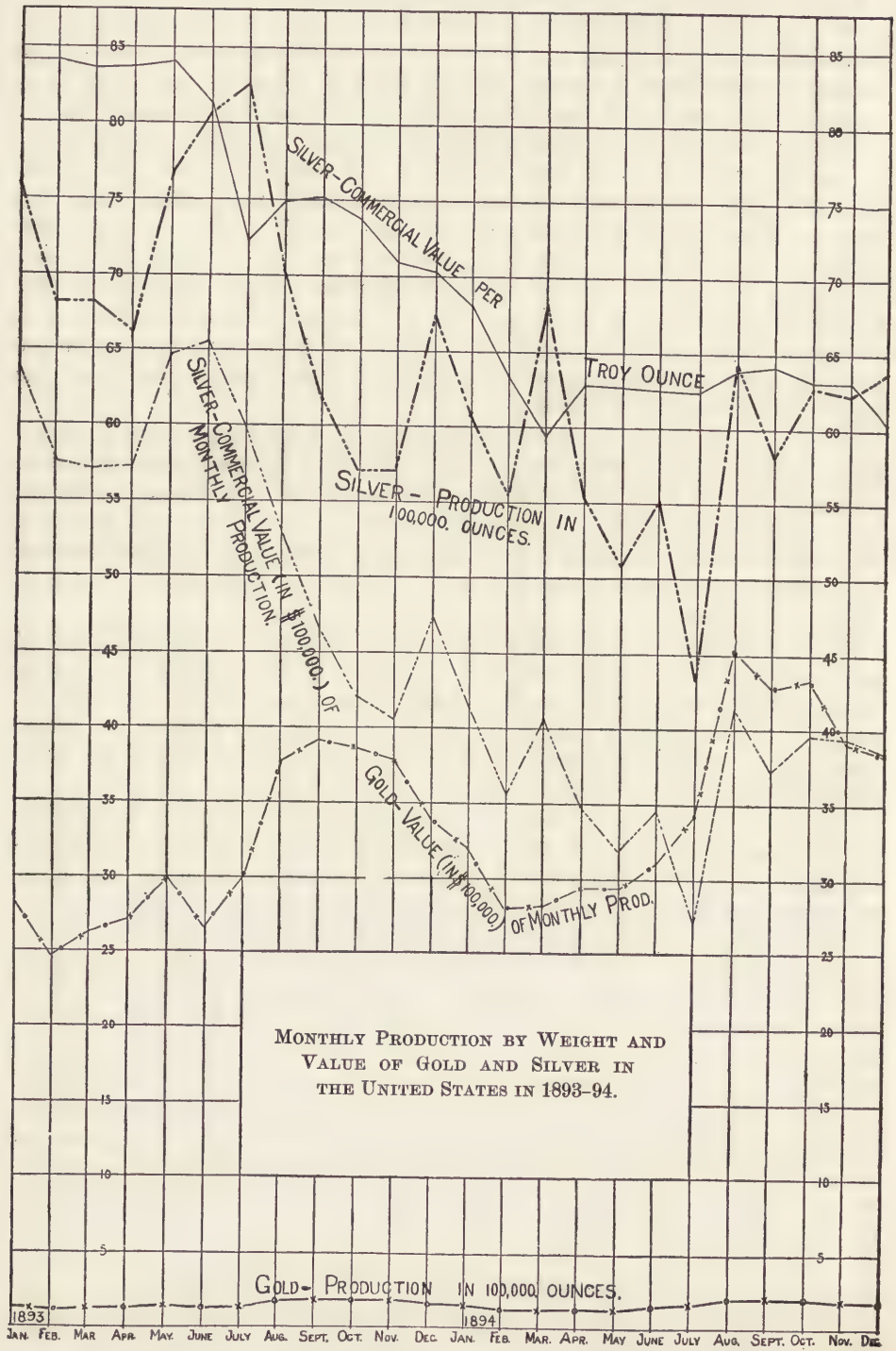
Silver production has declined again in the United States, and in 1894 amounted to only 49,846,875 fine ounces or 10,653,125 ounces (17.6%) less than in 1893, and less than in any year since 1888. The decline in silver output will continue, for the bonanza mines in Colorado, Montana and Nevada are either exhausted or are approaching exhaustion, and few new silver mines are being opened or even prospected for.

The low price of the metal, and the widespread discontinuance of its use, both in money and in the arts, and the constant fear that the few silver basis countries still remaining may also stop its use, render the immediate future of the metal very uncertain and gloomy, and discourage investment in its production.

The progress in metallurgy has undoubtedly lessened very greatly, and, in a measure, equally, the cost of extracting gold and silver from their ores, but as this cost declines, lower and lower grade ores are treated, so that the cost of producing a large part of the output each year will always approach, and very often exceed, the commercial value of the metal produced. It is the rare and fortunate owner of the bonanza who profits by the reduction in the cost of winning the precious metals; the average producer, in constant expectation of finding richer ore, works down until there is little or no profit, whatever the commercial value of the metal may be; in fact the higher this is, and consequently the more valuable would be a bonanza, the more money will be lost in the search for ore and in working unprofitable ores.

THE WORLD'S PRODUCTION OF GOLD AND SILVER.

The following tables give a comparative statement of the production of gold and silver throughout the world in the years 1893 and 1894. In the great



MONTHLY PRODUCTION BY WEIGHT AND VALUE OF GOLD AND SILVER IN THE UNITED STATES IN 1893–94.

majority of cases the statements given are from direct returns, chiefly official, received from the different countries. In a comparatively few cases where we have not been able to secure such returns—for the reason that none are made—the amounts are estimated and for that purpose we have generally adopted the full and careful estimates made by the Director of the United States Mint.

The accompanying table is, we believe, the most complete statement of the production of the precious metals ever presented:

THE WORLD'S PRODUCTION OF GOLD AND SILVER. (*a*) (IN KILOGRAMS AND DOLLARS.)

Countries.	1893. 1 kg. gold = $664.60. 1 kg. silver = $25.14 (78.2c. per oz.)				1894. 1 kg. gold = $664.64. 1 kg. silver = $20.26 (63c. per oz.)			
	Gold.		Silver.		Gold.		Silver.	
	Kilo-grams.	Value.	Kilo-grams.	Commer-cial Value.	Kilo-grams.	Value.	Kilo-grams.	Commer-cial Value.
United States	55,098	$35,955,000	1,881,731	$47,306,717	59,824	$39,761,205	1,550,387	$31,403,531
Australasia	58,364	34,436,794	637,800	16,034,292	68,440	40,051,875	562,263	11,388,638
Mexico	1,964	1,305,000	1,380,116	34,696,116	6,771	4,500,000	1,463,361	29,640,378
Russia	43,000	28,577,800	10,117	254,341	41,598	27,646,000	10,117	204,920
Germany	3,079	2,046,300	449,383	11,297,388	3,315	2,203,100	193,151	3,912,273
Austria-Hungary	2,035	1,352,461	60,975	1,532,912	2,535	1,684,800	61,319	1,242,016
Sweden	93	62,000	4,464	112,225	94	62,500	2,869	58,112
Norway	.....	.....	4,495	113,004	.....	.....	4,705	95,299
Italy	362	240,585	40,095	1,007,988	176	117,000	28,885	585,066
Spain	.....	.....	63,605	1,599,029	.....	.....	85,000	1,721,675
Greece	.....	.....	2,025	50,908	.....	.....	35,436	717,756
Turkey	10	7,000	6,334	159,236	12	8,000	1,516	30,707
France	300	199,380	98,077	2,465,655	279	185,300	98,077	1,986,549
Great Britain	72	47,850	8,525	214,318	99	65,800	7,932	160,662
Dominion of Canada	1,692	976,603	13,000	326,820	1,648	1,095,261	20,202	409,192
Argentine Republic	211	140,200	22,026	553,733	143	95,000	37,334	756,200
Colombia	4,353	2,892,800	52,511	1,320,126	4,353	2,892,800	52,511	1,063,610
Bolivia	101	67,000	372,666	9,368,823	101	67,000	684,418	13,862,888
Equador	79	52,000	240	6,034	103	68,400	240	4,861
Chile	2,162	1,436,600	54,800	1,377,672	698	464,400	88,680	1,796,213
Brazil	1,308	869,200	.....	.....	3,339	2,219,500	.....	.....
Venezuela	1,213	806,100	.....	.....	1,213	806,100	.....	.....
Guiana (British)	4,172	2,772,700	.....	.....	4,308	2,464,176	.....	.....
Guiana (Dutch)	1,074	713,800	.....	.....	872	579,500	.....	.....
Guiana (French)	1,502	998,200	.....	.....	2,000	1,329,200	.....	.....
Peru	110	73,000	59,257	1,489,725	112	74,400	107,670	2,180,856
Uruguay	213	141,600	.....	.....	213	141,600	.....	.....
Central American States	246	163,500	48,123	1,209,816	708	470,500	48,123	974,731
Japan	738	484,000	69,381	1,744,243	737	489,800	60,869	1,232,901
China	12,678	8,426,000	.....	.....	9,040	6,014,000	.....	.....
Africa	52,575	28,818,332	.....	.....	73,585	39,555,836	.....	.....
India (British)	6,548	3,788,246	.....	.....	6,507	3,766,251	.....	.....
Korea	884	587,900	.....	.....	703	467,200	.....	.....
Total	256,236	$158,437,551	5,339,746	$134,241,121	293,542	$179,345,704	5,205,065	$105,429,034
U. S. coinage value	.....	.....	.....	221,919,844	.....	.....	.....	216,358,937

(*a*) The above figures were derived as follows: United States, from figures compiled by the *Engineering and Mining Journal*. Australasia, from the official reports by the various colonial authorities. Germany, from *Vierteljahrshefte zur Statistik des Deutschen Reiches*. Austria-Hungary—Figures for Austria from *Statistisches Jahrbuch des K. K. Ackerbauministeriums;* the Hungarian figures were kindly sent by the Hungarian Royal Statistical Office. Sweden, from special communication to THE MINERAL INDUSTRY by the *Statistiska Centralbyrau*, Stockholm. Italy, from *Relazione General sul Servizio Minerario*. Spain, from the official report, *Estadistica de Minera España*. France, from the official annual report, *Statistique de l'Industrie Minérale*. Great Britain, from the annual report on mineral statistics in the *Mines and Minerals Series*. Dominion of Canada, from revised report of the Canadian Geological Survey. British Guiana, from the official annual report of the Commissioner of Mines, Georgetown. Japan, from a communication to THE MINERAL INDUSTRY by T. Yamanouchi, Director of the Mining Bureau, Tokio. Statistics of Mexico, Norway, Greece, Turkey, the South American States, exclusive of British Guiana, China, India and Korea, were compiled by the Director of the United States Mint.

It will be seen that we have given the commercial value of silver and not its coinage value at our own or any other established ratio. We have done this because the silver is sold all over the world at its commercial value, and that is the return which it brings to its producers. We have, however, for purposes of comparison, added to the totals the value which the silver would possess at the

United States coinage ratio. In this table and in the returns generally the production of silver is given in kilograms of fine metal, that is of pure silver. Unfortunately, however, the returns of gold production are not made in the same way, and the value of the gold varies somewhat; thus in the South African returns it is customary to value the gold from the mill workings at £3 10s. per oz., and from the cyanide process at £3 per oz., the average of all the product giving a metal of about .800 fine. In the Australian colonies the value varies from about .825 fine upward, the average of all the Colonies being in the neighhood of .875 fine. Our own United States returns are always made in fine gold.

The United States has lost the first place as a gold producer, its production in 1894 having been exceeded by that of Australasia by $290,670. The production of the Transvaal, South Africa, reduced to fine gold, was $37,883,263, or less than that of the United States by $1,877,942. Estimating the production of other countries in Africa, the gold output of the whole continent was still less than that of the United States by $205,000. Russia holds the fourth place, its output falling $12,115,205 below that of the United States. Notwithstanding the increase in our gold production it is altogether probable that during the present year the order of producers will change and the Transvaal will hold the first rank. Whether the second will fall to our own country or to Australasia is exceedingly doubtful. No other country in the world begins to approach these four leaders in the extent of its production of the yellow metal, and the four together furnish very nearly five-sixths of the whole amount.

In the following pages we have given some notes of the production of the precious metals by countries, arranging them according to continents.

NORTH AMERICA.

Canada.—The gold production of Canada comes chiefly from the provinces of British Columbia on the Pacific coast, from Nova Scotia on the Atlantic coast, and from the extreme western part of Ontario. The details of this production will be found in the article on Canada on another page. The gold production of Nova Scotia is not increasing, and the mines of that peninsula have not been worked in recent years to the same extent as before the discovery of the richer fields of the West. Nevertheless, there is a steady output from a number of small mines, although of recent years there has been but little prospecting done and hardly any opening of new districts.

The mineral wealth of British Columbia is undoubtedly very large, although its development has been somewhat delayed from the fact that most of its ores are of a complex nature and difficult to work. A considerable part of the gold of this province is found in connection with the silver ores, as in the adjoining States of Idaho and Montana. Practically British Columbia has its mines and their production of gold controlled by operators from the United States, as was to be expected from its proximity to the States of the Pacific coast and the long distance which separates it from the other settled portions of the Dominion. British Columbia produces the greater part of the silver which is credited to Canada, although a small portion of it is from Ontario.

The gold fields of the extreme western section of Ontario held their own, work continuing steadily in a number of mines. The newly discovered gold fields of the Rainy Lake region, which are partly in Canada and partly in the United States, are said to possess very extensive deposits of low grade ores which can be cheaply worked. They have not as yet, however, been sufficiently explored to determine their real value, and their addition to last year's output of gold was very small. A great deal of prospecting is going on and it is probable that these fields will be heard from during 1895.

Central America.—But little is to be said of the production of the Central American States. The output of gold in 1894 showed a very large comparative increase over that of 1893, but was not in itself large, reaching only a total of $470,500. The output of silver was practically the same in both years. The increase in gold was largely due to the working of placer mines in Nicaragua and Costa Rica. The rivers of the first named State are said to contain very rich gold-bearing gravels, but their exploitation has hardly been begun.

Mexico.—This country has followed the general tendency by showing a large comparative gain in the production of gold. In 1893 the value of the gold was only about 3½% of that of the silver; in 1894 it rose to about 14%. The fact seems to be that Mexico has been for so many years pre-eminently a silver mining country that its resources of gold have been somewhat neglected. Within the last year or two, however, a number of new companies have been formed, and the working of gold mines and prospecting for that metal have been actively pushed, with the effect shown in the tables. This increase in gold will probably continue, though hardly in as high a ratio as in 1894.

Mexico continues to be the largest producer of silver in the world, with the single exception of the United States, and in 1894 increased its production of the white metal by 73,245 kilos. By far the larger part of its product is exported as is shown by the following table, giving the exports of silver for the last fiscal year:

EXPORTS OF PRECIOUS METALS FROM MEXICO IN 1893–94. (*a*)

Substance.	July 1 to Dec. 31, 1893.	Jan. 1 to July 1, 1894.	Total.	Substance.	July 1 to Dec. 31, 1893.	Jan. 1 to July 1, 1894.	Total.
Argentif. copper ore...	$274,362	$102,854	$377,216	Coined gold (Mexican).	$51,423	$84,576	$135,999
Silver ore.....	3,937,801	5,085,795	9,023,596	Gold bars.....	59,251	96,703	155,954
Coined silver.....	11,654,644	5,731,694	17,386,338	Gold with silver.....	245,162	235,728	480,890
Slags	4,100	56,490	60,590	Gold ore.....	54,569	1,230	55,799
Silver bars.....	1,512,315	1,618,508	3,130,823				
Silver with gold.....	2,581,056	2,169,664	4,750,720	Total.....	$410,405	$418,237	$828,642
Sulphide of silver.....	456,261	300,840	757,101				
Argentiferous lead.....	4,680,589	5,246,735	9,927,324				
Total.....	.....	.....	$45,413,708				

(*a*) From *Boletin Semestral de la Direccion General de Estadistica*, Mexico, 1894. Value in Mexican dollars.

The large proportion of the silver which is exported in the form of coin is due to the well-known fact that the Mexican dollar has a currency throughout the far East which is possessed by the coin of no other country, and that in the markets of the world it consequently commands a premium over its actual bullion value. The exports of silver ore are decreasing, as we have noted elsewhere, while those of silver contained in lead bullion are increasing.

The following table shows the production of gold and silver in Mexico for the six years ending with 1894. The statistics for the years previous to 1889 can be found in THE MINERAL INDUSTRY, Vols. I. and II.

PRODUCTION OF GOLD AND SILVER IN MEXICO.

Year.	Gold.		Silver.		Year.	Gold.		Silver.	
	Kilos.	Dollars. (a)	Kilos.	Dollars. (a)		Kilos.	Dollars.(a)	Kilos.	Dollars. (a)
1889....	1,053	$700,000	1,143,985	$47,544,000	1892....	1,699	$1,129,200	1,228,994	$51,077,000
1890....	1,154	767,000	1,211,646	50,356,000	1893....	1,964	1,305,300	1,380,116	57,357,600
1891....	1,505	1,000,000	1,084,100	45,055,200	1894....	6,771	4,500,000	1,463,361	(b)29,640,378

(a) Kilogram of gold, $664.60; kilogram of silver, $41.56, United States coinage rate. (b) Commercial value.

The development of Mexican production has been rather in the direction of improvements in the methods of mining and the adoption of new machinery than in the opening of new mines. In other words, the increased output has come from new developments rather than from new districts. The extension of railroads into many parts of the republic in recent years has had the effect of decreasing very much the cost of machinery delivered at the mines, and this is having its natural effect. There is no reason to expect a reduction in the Mexican output of silver for many years to come, and this seems to be plainly shown by the fact of the considerable increase made in 1894, in spite of the unfavorable influence of the low price of silver, and in spite also of the fact that none of the great mines were in bonanza.

SOUTH AMERICA.

Argentine Republic.—The Argentine Republic is a small producer of both gold and silver. The silver is mined chiefly in the western part of the country, and the production last year showed a considerable decrease. Gold showed a slight increase, principally, we understand, from the placer workings in Argentine Patagonia.

Bolivia.—The gold production of this country is comparatively limited and has remained practically the same for a number of years. The following table shows the value of the silver produced in the five years ending 1894:

Year.	Value.	Year.	Value.	Year.	Value.
1890.....	$7,698,326	1892.....	$7,453,935	1894.....	$13,862,888
1891.....	7,440,085	1893.....	9,368,823		

Silver last year showed a large increase, which is partly the result of the completion two years ago of railroad connection with the coast, and partly also of the activity which has been shown in the great Huanchaca and other mines. Bolivia has been a notable silver producer from the earliest times of the Spanish discoveries, and the increase made last year carried it to the third rank as a silver producer, its output being exceeded only by that of the United States and Mexico.

Brazil.—Little is to be said of the gold and silver production of Brazil. Silver is not mined in that country, but gold showed some increase. The great

mines of the Ouro Preto Company and of St. John del Rey have both suffered from a period of small production and from difficulties arising in large measure from the systems of mining and working adopted. Both promise a considerable increase in the future, but in the meantime the gold production of these mines has declined.

Chile.—Chile produces a small amount of gold, and last year showed a considerable falling off. The silver production also shows a decrease; while the latter has been considerable, the chief wealth of Chile has always been in its copper and other mineral products and it has not been especially prominent as a producer of the precious metals.

Colombia.—The gold and silver production was practically the same for both the years under review. The possibilities of gold mining in this country are believed to be very great, but the mines are as yet only partially developed.

Ecuador.—The production of this country is small and very little has been done toward the development of the mineral resources which it undoubtedly possesses.

Guiana.—No silver is produced in any of the colonies under this name, and so far the gold output has been entirely from placer workings in the numerous rivers which find their way toward the sea from the region lying to the southward. Two companies have been formed and are operating quartz mines in British Guiana, but so far we believe their operations have been altogether preliminary and the quartz mills have added nothing to the production.

The following tables give the production of the Guianas in details:

GOLD PRODUCTION OF THE GUIANAS.

	British Guiana.		Dutch Guiana.		French Guiana.
Year.	Kilos.	Value.	Kilos.	Value.	Kilos.
1890	1,947	$1,124,766	952	$524,319	1,342
1891	3,150	1,801,389	821	452,158	1,511
1892	4,031	2,303,163	944	627,025	1,482
1893	4,441	2,542,996	1,098	729,059	2,000
1894	4,308	2,464,176	872	579,600	2,200

The region which is now in dispute between Venezuela and Great Britain, the latter country claiming it as a part of British Guiana, contains very rich placer mines, and the same is said of the district which is in dispute between Brazil and France, on the southern boundary of French Guiana.

Peru.—The silver production of Peru increased last year, chiefly on account of the reopening and extension of workings in old mines which has been made possible by the completion of the Lima & Oroya Railroad. The gold production of Peru is not large and varies but little from year to year.

Uruguay.—This country produces some gold, chiefly from placer workings; there are also some mines worked by French companies, but so far without notable success. Not much is known about its mineral resources, which have been but little developed.

Venezuela.—The gold production of Venezuela remains practically unchanged. An effort has been made to increase the amount of foreign capital invested in the development of the mines of this country but so far without very much

success owing to various causes, chief among which has been the failure of El Callao mine, which is now practically exhausted. The gold cutput was 39,009 oz. in 1894, against 34,537 oz. in 1893; 31,931 oz. in 1892; 44,774 oz. in 1891, and 49,432 oz. in 1890.

EUROPE.

No European country outside of Russia is a large producer of the precious metals. Nevertheless there is an output which in the aggregate is not inconsiderable.

Austria-Hungary.—The gold production comes chiefly from the Hungarian mines, although there are some small workings in Austria; the amount is gradually increasing. Silver is found in both countries; the production is regulated chiefly by the government, which owns most of the mines from which it is taken. The greater part of the output is made in connection with lead and other ores.

France.—This country reports a small production of gold, which is not increasing. The silver output shows but little change and is made chiefly from the lead and zinc ores of the Pontgibaud and other mines.

Germany.—The gold produced in this country is not inconsiderable in amount and a large quantity of silver is also produced. The chief sources of the silver are the mines of Freiberg in Saxony, where it is taken out in connection with other metals; the copper mines of Mansfeld, which carry some silver, and the mines of the Harz. As in several other of the European countries mentioned, the mines are worked for other metals chiefly, and the silver may be considered as a by-product.

Greece.—This country has a small production of silver, chiefly from the Laurium lead and zinc mines, which has increased considerably during the past few years.

Italy.—The gold production of Italy is variable; it comes from the placers of Piedmont. The silver is found chiefly in connection with the lead and zinc ores in Sardinia and on the mainland.

Norway.—The production of silver in this country is small and varies but little from year to year, the silver being here also a by-product.

Russia.—As we have already noted, Russia is the fourth gold producer in the world, and has for many years been prominent in that respect. A description of the gold mines in Russia and their methods of working will be found on another page, in the article upon that country.

Spain.—The silver production is considerable and comes entirely from the lead mines. A large proportion of the Spanish lead is argentiferous and furnishes the precious metal reported.

Sweden.—This country has a small output of gold, and also of silver, but the amounts supplied are of very slight importance.

Turkey.—So far as can be ascertained last year the production was trifling, only 12 kilos of gold and 1516 kilos of silver being reported. Owing to the defective administration of this country, however, the statistics of its mineral production cannot be ascertained with any certainty, and any output of gold especially would be concealed, if possible, from the knowledge of the government.

United Kingdom.—There have been two sources of gold production in Great Britain; the placer workings of Sutherlandshire in Scotland, and some small ore mines in North Wales. The Scotch placers are not at present operated, owing to the refusal of the owner to permit mining. They have been operated at times, but never with important results. In Wales gold mining has been carried on steadily, though to a limited extent, for a number of years, and recently some new discoveries have been reported made which promise to be of considerable value. The silver of the United Kingdom is found in connection with lead and other ores.

ASIA.

Unfortunately in most Asiatic countries statistics are difficult to obtain, and the figures as to the output of this great continent are largely conjectural.

British India.—Gold has been produced in British India since very early times, and the oldest historical records which we have make mention of gold as found in different parts of the country. At present the most important field is the Colar gold field in Mysore, which is worked actively by a number of English companies, the more important of which are the Champion Reef, the Ooregum and the Nundydroog. The companies named have been fairly successful and for several years have paid good dividends to their owners. There are a number of smaller companies which have not yet reached the point of paying a profit. The working of this field is likely to be extended in the future. The gold is generally found in quartz veins and can for the most part be worked by free milling and amalgamating processes. In the following table the tonnage treated and the gold produced by the companies working in the Colar gold field are shown:

Company.	1893.		1894.	
	Tons.	Ounces.	Tons.	Ounces.
Ooregum	62,822	75,023	45,294	68,224
Champion Reef	22,075	31,416	44,644	53,516
Mysore	48,708	65,409	60,756	52,115
Nundydroog	25,760	31,223	29,730	29,745
Balaghat	5,640	7,252	4,265	5,322
Mysore Reefs	.....	.....	349	325
Total	165,005	210,453	185,038	209,247

Since regular crushings commenced, in 1884, nearly 688,000 tons of quartz have been milled from the Indian mines, producing gold of the value of about £3,726,000, or about £5 8s. for every ton of quartz treated. Few of the Indian companies started between 1879 and 1885 have proved successful; but the reason is to be found mainly in the fact that the Wynaad district, which was the first opened and worked, and about which the balance of expert opinion was very sanguine, proved completely unworkable on a commercial basis.

China.—There has been much discussion over the actual gold production of this largely unknown country. From such data as could be obtained the Director of the Mint has estimated its output of gold as considerable, amounting to 9049 kilos in 1894 against 12,678 kilos in 1893. No silver is credited to

China, which is a mistake, but there are no accurate statistics upon this point. The output is small. In 1893 China exported $12,643,783 in gold, according to the customs returns, and imported $5,142,814, showing an excess of exports amounting to $7,500,969. On the other hand the silver exported during that year was $37,612,051, while that imported was $49,515,467, showing an excess of imports amounting to $11,903,416.

Korea is a producer of gold, and is reported to possess considerable deposits of gold ores. The exports of gold were $918,659 in 1893, and $852,751 in 1892.

Japan.—The production of gold is small and shows little change. The output of silver is increasing as the mines are more extensively worked, and the ores more carefully and scientifically treated.

Philippine Islands.—During 1893 several discoveries of gold were made in this Spanish colony. Small quantities of alluvial gold had been obtained for many years previously. In 1894 two English companies obtained concessions to work these deposits and after some exploration decided to put up machinery. The new district will be a producer in 1895.

AFRICA.

Small amounts of gold from Central Africa and from the East and West African coasts have come into the world's stock at intervals for a great many years. From the time the Cape Colony was first settled by Europeans there were always rumors of gold deposits existing in the interior, and from time to time small discoveries were made in the northern part of Cape Colony and in Natal. It was not until the discoveries of gold were made in the Transvaal, however, that the output assumed importance. The rapid and extraordinary growth of the gold production of that country is a matter of recent history, and within a few years the Transvaal has risen from a practically unknown country to be the third gold producer in the world, with a strong probability that in another year or two, at most, it will be the leading producer of the yellow metal. Moreover, this region is of interest in that it differs in many respects from any other gold field in the world in the nature of its ores and method of their occurrence. The African gold regions are also peculiar from the fact that they contain few or no placer workings; but little gold is found in the river beds or in alluvial workings, and almost the entire supply is obtained from deep ore mines. This fact is one of the reasons why the discovery of gold deposits was postponed for so many years. In California and in Australia it was the placer mines which were first worked and which for a long time furnished the greater part of the supply, but in South Africa it was not until careful exploration had revealed the existence of gold-bearing beds hitherto unsuspected, that the wealth of the country was known, and even then the discoverers had much difficulty in making themselves believed.

The chief mining district of the Transvaal at present, although it was not the first opened, is the Witwatersrand, which contains a large gold-bearing area within comparatively narrow limits and which supports a greater number of successful companies than any other gold region in the world. The extraordinary regularity and permanency of the so-called "Banket" beds have made the Witwatersrand a notable region, and no equal area in the world has ever before produced so large an amount of the precious metal.

The following tables give some statistics of the production of the Witwatersrand and of the minor districts of the Transvaal for a series of years, and show the rapid growth of the production of the country:

GOLD PRODUCTION OF THE TRANSVAAL.

District.	1893.	1894.
	Ounces.	Ounces.
Witwatersrand	1,478,473	2,024,164
DeKaap	70,386	92,577
Lydenburg	31,500	60,275
Klerksdorp and Potchefstroom	24,407	77,714
Zoutpansberg	5,276	10,629
Malmani	.....	494
Total	1,590,042	2,265,853

The usual valuation of Transvaal gold, as given by the Johannesberg Chamber of Mines, is £3 10s. per oz. for mill gold and £3 for cyanide gold.

The production of gold of the Witwatersrand district by months since the beginning is given in the following table:

GOLD PRODUCTION OF THE WITWATERSRAND DISTRICT.

Months.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.
January	.....	7,328	25,506	35,007	53,205	84,560	108,374	149,814
February	.....	12,180	22,457	36,887	50,079	86,649	93,252	151,870
March	.....	11,976	27,919	37,780	52,949	93,245	111,474	165,373
April	.....	14,146	27,029	38,697	56,372	95,562	112,053	168,745
May	887	13,397	35,028	38,836	54,673	99,436	116,911	169,774
June	734	12,773	30,878	37,419	55,863	103,252	122,907	168,162
July	240	16,687	31,091	39,457	54,924	101,279	126,169	167,953
August	1,409	18,616	30,520	42,864	59,070	102,322	136,069	174,978
September	1,936	20,242	34,143	45,486	65,602	107,852	129,585	176,708
October	4,029	27,165	32,214	45,249	72,793	112,167	136,682	173,379
November	5,463	26,827	33,722	46,783	73,394	106,795	138,640	175,304
December	8,457	26,784	39,050	50,352	80,323	117,748	146,357	182,104
Total	23,155	208,122	369,557	494,817	729,238	1,210,867	1,478,473	2,024,164

The production of gold of the principal mines on the Witwatersrand is given in the following table:

TOTAL PRODUCTION OF LEADING WITWATERSRAND MINES.

Mines.	1889.	1890.	1891.	1892.	1893.	1894.
	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.
Robinson	75,038	71,828	94,059	170,140	161,138	145,392
Langlaagte Estate	61,755	56,750	51,462	88,981	104,910	146,369
New Primrose	3,626	12,795	23,080	56,475	83,779	89,021
Crown Reef	18,364	37,500	39,841	70,212	82,089	120,546
Durban-Roodepoort	14,539	16,017	23,155	30,932	60,634	61,009
Ferreira	.....	.....	44,561	48,233	55,674	66,047
City & Suburban	18,814	13,073	12,409	29,125	46,811	75,265
Nigel	3,698	13,600	18,145	50,287	46,008	51,549
Jumpers	21,778	30,230	16,818	20,946	43,392	62,482
Simmer & Jack	12,551	21,262	38,409	38,146	39,670	61,724
New Rietfontein	.....	.....	.....	11,555	35,318	21,672
Meyer & Charlton	4,970	15,586	20,620	22,332	34,182	33,859
Jubilee	6,510	12,332	9,285	17,319	30,064	27,075
Randfontein	.....	.....	.....	6,586	29,935	42,133
Wolhuter	1,548	6,846	.....	11,093	25,951	30,598
May Consolidated	9,948	13,089	27,400	28,385	24,945	39,106
Wemmer	8,384	7,017	13,960	16,522	24,922	43,175
Salisbury	9,303	8,508	12,397	20,825	24,857	20,723

For a time after the first discovery, all gold mining in the Transvaal seemed to be in doubt. It was true that exploration showed the existence of gold throughout the district, but many mistakes were made, as in all new regions, and nearly all of the companies at first started work in an extravagant way. The gradual introduction of improvements, of rational methods of working, and of close economy in expenses has changed the condition of affairs. How great the improvement has been is shown by the fact that while at first it was not considered possible to work at profit ores containing less than from 1 oz. to 1½ oz. per ton, some of the largest companies are now paying dividends from ore running not much over half an ounce. A great part of the success attained has been due to American mining engineers, some of whom were called upon at an early period in the history of the Witwatersrand, and a large number of whom are now managing important mines there.

The production of the Witwatersrand mines for the years 1893 and 1894 is analyzed as to its sources as follows:

	1893.	1894.
	Oz.	Oz.
From mill	1,056,383	1,305,409
From concentrates	62,737	84,580
From tailings	304,498	587,389
From alluvial	1,975	965
From other sources	52,884	45,821
Total	1,478,477	2,024,164

As an interesting example of the working of a Transvaal mine we may take the report for 1894 of the Robinson Company, which was during that year the largest gold producer. The company had 60 stamps at work in its mills for seven months of the year, and 70 for the remaining five months. The total ore mined and worked was 107,935 tons. There were 2997 tons of pyrites saved by concentration and treated by chlorination, and 70,525 tons of tailings from the mill were treated by the cyanide process. The total amount of gold obtained and the averages per ton of ore milled were as follows:

PRODUCTION OF THE ROBINSON MINE, TRANSVAAL.

	Total Ounces	Ounces per Ton.	Value per Ton
From mill (amalgamation)	110,962	1.028	$17.89
From concentrates (chlorination)	14,217	0.132	2.58
From tailings (cyanide)	20,213	0.187	2.91
Total	145,392	1.347	$23.38

The cost of working per ton was as follows: mining, $3,44; milling, $0.94; repairs of buildings, dam, etc., $0.14; general expenses, $0.69; total, $5.21.

The cost of the mill work in detail was as follows: Transportation of ore to mill, 1.88c.; rock breakers, 9.94c.; mill labor, 12.84c.; supplies, 14.66c.; fuel, 16.48c.; water supply, 7.78c.; mill maintenance and repairs, 8.40c.; concentrating, 15.60c.; maintenance of concentrating plant, 3.38c.; assaying and smelting, 2.80c.; total, 93.76c.

As the working of the tailings by cyanide process is an important part of the mining industry on the Witwatersrand the cost of this process as given in the Robinson Company's report will also be of interest. The total quantity of tailings treated in 1894 was 70,525 short tons; the extraction was only 64.2% of the assay value. The bullion returns were 20,213 oz., and the fine gold in this bullion was 15,731 oz. This gives an average of 0.223 oz. fine gold per ton of tailings, or $4.51, and a profit of $3.58 per ton. The cost was distributed as follows: Wages, 19.08c. per ton; general supplies, 9.14c.; fuel, 6.62c.; cyanide (0.62 lb. per ton), 29.58c.; zinc (0.21 lb. per ton), 1.90c.; filling and discharging vats, 26.96c.; total, 93.28c. per ton of tailings worked. This is said to be the lowest cost of cyanide treatment yet reached on the Transvaal, and is largely due to the fact that the arrangements made in the Robinson mill are such that the tailings are handled automatically throughout and very little labor is required.

A danger which threatens the Transvaal mines in the immediate future is the scarcity of labor, and, although steps have been taken to obtain all the natives possible, the rapid extension of operations has made the supply unequal to the demand. The native Kafir or Zulu works well under direction, but he is not a steady worker, and after earning what he considers a sufficient supply of money is very apt to leave the gold districts entirely and return to his own kraal. The labor is constantly changing and the difficulties in the way of increasing the supply are very great. It is feared that the result in the near future must be either a decrease in production or an increase in expenses.

The explorations carried on in the Witwatersrand indicate that the production is likely to increase for some time to come. The area exploited is continually increasing, and in another year at the latest the so-called deep-level companies which are sinking shafts to work on the continuation of the banket veins beyond the limits of the present mining areas will become producers. There are, of course, many varying opinions as to the length of life of the different mines, but there is little doubt that most of them can be assigned a considerable duration. The concurrence of opinion of various experts who have examined the region is that the Witwatersrand will reach its maximum production about the year 1900, and will continue at or near that maximum probably for ten years longer.

The other regions of the Transvaal, although less noted than the Witwatersrand, have also produced a considerable quantity of gold, as will be seen from the tables above. The newer regions of Mashonaland and Matabeleland also promise to become producers at an early day. Mashonaland especially, since its conquest by the British South Africa Company, has been covered with mining claims, although there are comparatively few instances where active working has been begun. The year 1895, however, will probably see a considerable change in this respect.

The other African production is not large, and its amount is necessarily estimated. Gold is found on the west coast of Africa; it is also known to exist north of the British possessions, in the Zambesi country, and at various localities in the Soudan. Gold has also been found in the Island of Madagascar, and the discoveries there will probably be extended should the French succeed in conquering and colonizing the country as they intend to do.

AUSTRALASIA.

The production of gold in Australasia showed in 1893 and 1894 the effects of the impulse which has increased gold mining all over the world during recent years, and to this in some of the colonies were added special causes for a gain.

The following table shows the production of gold in the Australasian colonies for five years ending with 1894; the figures for the years previous to 1890 can be found in THE MINERAL INDUSTRY, Vols. I. and II.:

PRODUCTION OF GOLD IN AUSTRALASIA. (*a*)

Year.	New South Wales.		Victoria.		New Zealand.		Queensland.	
	Ounces.	Value.	Ounces.	Value.	Ounces.	Value.	Ounces.	Value.
1890.....	127,760	£460,285	588,560	£2,354,240	193,193	£773,338	610,587	£2,137,054
1891.....	153,336	558,306	576,399	2,305,596	251,996	1,007,448	576,439	2,017,537
1892.....	156,870	569,178	654,456	2,617,824	238,079	954,744	615,558	2,154,453
1893.....	179,288	651,286	671,126	2,684,504	226,811	913,138	616,940	2,159,290
1894.....	324,787	1,156,727	673,680	2,694,720	221,533	886,132	679,511	2,378,288

Year.	Tasmania.		South Australia.		Western Australia.		Total Production.		Total Value.
	Ounces.	Value.	Onnces.	Value.	Ounces.	Value.	Ounces.	Kilos.	
1890.....	20,510	£75,888	26,086	£91,301	22,806	£86,394	1,589,502	49,439	$29,054,800
1891.....	38,789	145,459	28,700	100,450	30,311	115,183	1,455,970	45,286	30,365,988
1892.....	45,110	174,070	*a*28,700	100,450	59,548	226,284	1,798,341	55,935	33,985,015
1893.....	37,687	141,326	33,820	106,093	110,891	421,386	1,876,563	58,367	34,436,794
1894.....	57,873	202,555	35,844	125,454	207,131	787,099	2,200,359	68,440	40,051,875

(*a*) The sources from which the above figures have been derived are as follows for 1893: New South Wales, from the Statistical Survey, value calculated at £3 12s. 4d. per Troy oz. Victoria, from the annual report of the Secretary for Mines, value calculated at £4 per Troy oz. New Zealand, quantity entered for export in the official Report on Minerals and Mining. Queensland, from the annual report of the Under-Secretary for Mines, value calculated at £3 10s. per Troy oz. Tasmania, from the report of the Secretary for Mines. South Australia, from *A Statistical Account of the Seven Colonies of Australia*, by T. A. Cochlan, Government Statistician of New South Wales. Western Australia, quantity entered for export from the Western Australian Year-Book. Figures for 1894 are from Mr. P. F. Sellheim, Department of Mines, Brisbane, Queensland, except for New South Wales, which is from the official report.

The total value of the gold production last year—$40,051,875—brings Australasia to the front rank among the world's gold producers.

New South Wales.—The increase shown in 1894 of 145,499 oz., or 81%, was due in great part to the opening of new and the re-working of old placers. As noted elsewhere, the Australasian colonies suffered during 1893 and 1894 from a business depression even greater than that which prevailed in our own country; manufacturing was stopped in great part and large numbers of men who had found employment in the cities were idle. In this crisis the colonial authorities offered to those who were disposed to seek their fortunes in the mines an outfit and some assistance toward maintaining them until wages could be earned. This was accepted by large numbers of men, many of whom had been formerly employed in the mines but had left them for the more attractive work in the cities. In many cases these "fossickers," as they were locally called, secured some degree of success, and a large proportion of them were able at least to provide for themselves. It was very largely from this source that the gold production of New South Wales was increased during the year.

New South Wales also furnishes nearly all the silver production of Australasia. This metal comes chiefly from the silver-lead mines. The production of Broken Hill and other points on the Barrier Range has varied somewhat, and in recent years has shown a decrease, owing chiefly to the exhaustion of the richer ores nearer the surface compelling the companies to fall back upon the lower grade ores, of which large quantities had been held in reserve.

New Zealand.—This is the only one of the Australasian colonies which shows a decrease; the production of gold in 1894 was less by 5278 oz. than that of 1893. This is due to the partial working out of the placer mines and to the fact that the vein mines, as depth increases, generally yield ores of a complex character, the treatment of which has involved a number of experiments not always successful. At present it seems as if chlorination and the cyanide processes will solve the problem and that the gold production of New Zealand will hereafter increase.

Queensland.—This colony, which for a number of years has ranked second in Australasia as a gold producer, in 1894 showed an increase of 62,571 oz. over 1893, and this gain placed it the first in rank among the colonies. The condition of affairs in Queensland was very similiar to that already described for New South Wales, and much the same policy was adopted as in the other colony. The result was that the increase was widely distributed and came from many districts; no notable discoveries or new mines of extraordinary value are reported.

South Australia.—This colony shows a small increase, but proportionally a very good one. It produces less gold than any other of the colonies. It has, however, a larger extent of unexplored territory and is still very thinly populated, so that there are many possibilities of growth for the future.

Tasmania.—This colony shows a very considerable increase in its gold production, which is due to the opening of one or two new districts where work has been diligently prosecuted. The mining operations in Tasmania have hitherto been confined chiefly to the coast, the mountainous and difficult nature of the interior and the extraordinarily dense tropical forest growths making exploration exceedingly difficult. Within the last two years, however, much has been done in the way of opening the interior of the island, and it is probable that the next few years will see a considerable development of the mineral production.

Tasmania produces some silver, chiefly in connection with its lead and copper ores.

Victoria.—This colony showed a smaller proportionate increase in production than any of the other divisions of the Australasian mainland. The increase in 1894 was only 2554 oz., or 3.6%, over 1893. As already noted, this light increase lost the colony the first rank as a gold producer, and it was last year passed in output by Queensland. The comparatively small growth was due to the fact that the greater part of the output of Victoria is from deep mines, and while most of these work steadily and successfully through the year there was very little increase in placer mining and no new or marked development in other respects.

Western Australia.—This colony nearly doubled its gold output in 1894, reporting a total of 207,131 oz. against 110,891 oz. in 1893. Most of this

increase came from the Murchison and Coolgardie districts. The last named district has created a sensation almost all over the world by the extraordinary richness claimed for the first discoveries. It drew miners and prospectors from every quarter of Australasia, and some even from our own country, but most of them failed to meet with success. Undoubtedly some very rich ore has been taken out at Coolgardie, but, as is frequently the case where such deposits are opened, they have proved as a rule to be very unreliable, and a rich pocket may be followed by a long period during which nothing is taken out of the mine but barren rock. This pockety or variable nature characterizes nearly all of the mines so far opened in this district, and while a considerable amount of gold has been taken out, the returns to the owners of the properties have been extremely variable. The richness of some of the discoveries has been made use of to float an enormous number of companies in England, and a very large amount of capital has been subscribed to these organizations. The amount of actual work done, however, is still comparatively limited, although many additions will be made to the plants in operation during the current year. The natural conditions are so unfavorable that gold mining in the district must always remain a costly operation, as the Coolgardie country is practically a desert with a very limited supply of water. At certain seasons, in fact, the water supply has been so limited that there was great suffering among the miners, and operating mills was out of the question. Work has been begun on a pipe-line to convey water some 60 miles for the supply of the region, but this will be necessarily an expensive operation and water must remain too costly to be freely used. The government of Western Australia has also a railroad in progress, but it is not likely to reach the district for two years to come. Under these circumstances the profit from Coolgardie mines must be considered as very uncertain, and mining is likely to remain a speculative enterprise entirely. This new gold region presents a most marked contrast to South Africa, where gold mining has been a more certain and regular industry than anywhere else in the world.

THE MOVEMENT OF GOLD AND SILVER.

The following table shows the imports and exports of gold and silver in the United States for the five years ending with 1894, as given by the United States Bureau of Statistics:

UNITED STATES IMPORTS AND EXPORTS OF GOLD AND SILVER. (*a*)

Year.	Gold in Ores.		Silver in Ores.		Gold Coin and Bullion.		Silver Coin and Bullion.	
	Imports.	Exports.	Imports.	Exports.	Exports.	Imports.	Exports.	Imports.
1890.....	$149,366	$32,094	$8,356,412	$1,126,697	$24,063,074	$20,230,090	$26,539,789	$22,426,119
1891.....	233,269	100,918	9,717,443	1,090,514	79,086,581	44,970,110	27,692,879	18,192,750
1892.....	714,110	9,262	9,726,704	1,592,931	76,532,056	17,450,946	35,975,834	21,726,252
1893.....	518,186	*b*276,933	9,490,892	.....	79,775,820	72,762,389	46,288,721	18,274,804
1894.....	743,046	*b*231,413	7,809,186	.....	101,819,924	20,607,561	47,044,205	9,824,408

(*a*) From reports of the Bureau of Statistics, United States Treasury.
(*b*) In 1893 and 1894 gold and silver in ores were not reported separately.

The imports of gold and silver in ore and bullion refined in the United States were ascertained from the smelters and refiners as follows:

	1893.	1894.
Gold	103,878 fine oz.	117,765 fine oz.
Value	$2,147,158	$2,434,202
Silver	23,221,811 fine oz.	20,842,711 fine oz.
Value	$17,159,656	$130,130,908

Owing to the mode in which the exports were made in the fiscal year 1893–94 it is impossible to separate exactly the gold and silver in ores. In the year 1892–93 the exports of gold and silver in ores were not given separately in the report of the Bureau of Statistics. The exports as given, it may be added, are only approximately correct.

The total amount of the coinage of the mints of the United States for five years past is shown in the following table, the total amounts being given at coinage values:

COINAGE OF THE MINTS OF THE UNITED STATES.

Year.	Gold.	Silver.	Year.	Gold.	Silver.	Year.	Gold.	Silver.
1890	$20,467,183	$39,202,908	1892	$34,787,223	$12,641,078	1894	$99,474,913	$6,024,898
1891	29,222,005	27,518,857	1893	30,038,140	12,560,935			

The following table shows the range of prices of silver in the London and New York markets for 1894 by months:

RANGE OF PRICES OF SILVER PER OUNCE.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
London, pence	30.31	29.18	27.28	28.95	28.69	28.68	29.82	28.29	30.88	28.69	31.41	27.78	29.13
New York, cents	67.91	63.43	59.49	62.92	62.96	62.59	62.45	61.83	64.14	63.06	65.13	60.43	63.00

The highest London quotation during the year was 31⅜d.; the lowest 27d. In New York the highest quotation was 69c.; the lowest 57⅞c. In London the price is per sterling ounce, or .925 fine; the New York price is always per fine ounce.

A very important element in the silver market is the amount of shipments to Eastern countries. These shipments, which are chiefly made from the London market, are recorded by Messrs. Pixley & Abell of London as follows, for five years past, as shown in the table below:

	1890.	1891.	1892.	1893.	1894.
India	£7,330,356	£4,462,754	£7,229,199	£7,052,271	£5,012,093
China	263,947	241,985	147,882	2,390,969	2,728,771
The Straits	912,606	2,209,966	3,826,739	1,612,513	1,233,446
Total	£8,506,909	£6,914,705	£11,203,820	£11,055,753	£8,974,310

In addition to the exports here shown there were shipped from London in 1893, £608,150, and in 1894, £955,800, to Japan.

GOLD PAR EQUIVALENTS.*

The Equivalent of One.	Sovereign.	Franc.	Mark.	Florin. Austro-Hungarian.	Florin. Dutch.	Rouble.	Escudo.	Kroner.	Milreis. Portuguese.	Milreis. Brazilian.	Piastre. Tunis.	Piastre. Egypt.	Piastre. Turkey.
Sovereign.....	.....	0.0396	0.049	0.099	0.0827	0.164	0.103	0.0551	0.222	0.1123	0.024	0.01025	0.0090
Franc.....	25.22	.....	1.24	2.500	2.086	4.133	2.600	1.3889	5.5997	2.8306	0.6051	0.2582	0.2277
Mark.....	20.43	0.81	.....	2.03	1.6898	3.35	2.106	1.125	4.5357	2.2928	0.4901	0.2091	0.1844
Florin, A. H..	10.09	0.40	0.494	.....	0.8344	1.653	1.04	0.5556	2.2399	1.1322	0.2425	0.1033	0.0910
" Dutch.	12.0909	0.479	0.592	1.198	.....	1.98	1.246	0.6658	2.6843	1.3569	0.2900	0.1248	0.1091
Rouble.....	6.103	0.242	0.299	0.605	0.5047	.....	0.629	0.3361	1.3551	0.6849	0.1464	0.0624	0.0551
Escudo.....	9.70	0.385	0.475	0.962	0.8023	1.59	.....	0.5341	2.1538	1.0887	0.2328	0.0977	0.0876
Kroner.....	18.16	0.72	0.888	1.800	1.5021	2.975	1.872	.....	4.0317	2.038	0.4357	0.1859	0.1639
Milreis, P.....	4.5041	0.179	0.225	0.447	0.3725	0.738	0.4643	0.2481	.....	0.5055	0.1081	0.0461	0.0407
" B.....	8.9104	0.3533	0.436	0.883	0.7369	1.46	0.919	0.4905	1.9712	.....	0.2138	0.913	0.0804
Dollar, U.S.A.	4.867	0.1929	0.238	0.4824	0.4025	0.7999	0.5017	0.268	1.080	0.5461	0.1167	0.0498	0.0439
" Mexico..	4.95	0.1962	0.242	0.491	0.4092	0.8106	0.51	0.2724	1.0984	0.5552	0.1187	0.0506	0.0446
" A. R ...	5.044	0.2	0.247	0.500	0.4217	0.8266	0.52	0.2778	1.12	0.5661	0.1210	0.0516	0.0455
" Chili,....	5.334	0.212	0.262	0.528	0.4412	0.874	0.55	0.2937	1.1317	0.5986	0.1279	0.0546	0.0481
" Uruguay	4.69	0.186	0.23	0.465	0.3878	0.7683	0.4834	0.2582	1.0411	0.5262	0.1125	0.0480	0.0423
" Ven.....	5.044	0.2	0.247	0.500	0.4172	0.827	0.52	0.2777	1.12	0.5661	0.1210	0.516	0.0455
" Bolivia..	5.215	0.207	0.255	0.517	0.4313	0.855	0.538	0.2871	1.1578	0.5853	0.1251	0.0534	0.0471
" Ecuador	5.125	0.203	0.251	0.508	0.4239	0.839	0.5283	0.2822	1.1377	0.5752	0.1229	0.0525	0.0463
" Nfld	4.8	0.1903	0.235	0 476	0.397	0.7861	0.4949	0.2644	1.0658	0.5388	0.1152	0.0491	0.0433
" P. I.	4.948	0.1962	0.242	0.491	0.4092	0.817	0.5109	0.2726	1.0986	0.5553	0.1189	0.0507	0.0447
Yen	4.89	C.194	0.239	0.484	0.4037	0.800	0.503	0.2688	1.0838	0.5478	0.1171	0.0499	0.0447
Toman.....	2.124	0.0843	0.104	0.210	0.1757	0.3481	0.219	0.117	0.4717	0.2384	0.0509	0.0217	0.0192
Rupee	10.273	0.4073	0.503	1.018	0.85	1.683	1.06	0.5657	2.2808	1.153	0.2465	0.1052	0.0927
Piastre, Tunis.	41.68	1.650	2.04	4.132	3.4471	6.829	4.26	2.29	9.2539	4.6408	.....	0.4266	0.3762
" Egypt.	97.69	3.87	4.782	9.683	8.0985	16.00	10.071	5.38	21.689	10.964	2.3439	.....	0.8819
" Turkey	110.71	4,392	5.423	10.98	9.1571	18.15	11.42	6.1003	24.595	12.4375	2.6578	1.134	.....

The Equivalent of One.	Dollar. U. S. A.	Mexican.	Argentine Republic.	Chilian.	Uruguay.	Venezuela.	Bolivia.	Ecuador.	Newfoundland.	Phillipine Islands.	Yen.	Toman.	Rupee.
Sovereign	0.2055	0.2021	0.1982	0.1875	0.2133	0.1982	0.1917	0.1951	0.2083	0.2029	0.2048	0.4707	0.0974
Franc	5.1826	5.098	5.0000	4.7284	5.3785	5.0000	4.8363	4.9214	5.2540	5.0971	5.1667	11.8720	2.4552
Mark	4.1979	4.1294	4.05	3.9603	4.3566	4.05	3.9174	3.9863	4.2557	4.1287	4.1850	9.6161	1.9887
Florin, A. H..	2.074	2.0392	1.9999	1.8918	2.1514	2.00	1.9345	1.9685	2.1016	2.0388	2.0667	4.7488	0.9821
" Dutch..	2.4845	2.444	2.392	2.2667	2.5784	2.3969	2.3185	2.3592	2.5187	2.4435	2.4768	5.6912	1.1874
Rouble.....	1.254	1.2337	1.21	1.1442	1.3015	1.2099	1.1703	1.1909	1.2714	1.2335	1.2503	2.8728	0.5941
Escudo	1.993	1.968	1.9229	1.8186	2.0686	1.923	1.8601	1.8928	2.0207	1.9605	1.9871	4.5661	0.9443
Kroner	3.7319	3.6706	3.6000	3.4043	3.8725	3.600	3.4822	3.5434	3.7827	3.6700	3.720	8.5477	1.7677
Milreis, P.....	0.9255	0.9104	0.8928	0.8444	0.9605	0.8929	0.8637	0.8788	0.9382	0.9143	0.9227	2.1201	0.4000
" B.....	1.831	1.81	1.7663	1.6704	1.9001	1.7856	1.7086	1.7386	1.8561	1.8007	1.8253	4.1942	0.8671
Dollar, U.S.A.	.....	0.9837	0.9645	0.9124	1.0378	0.9648	0.9332	0.9496	1.0137	0.9835	0.9969	2.2908	0.4737
" Mexico..	1.0165	.....	0.9807	0.9275	1.055	0.9808	0.9487	0.9653	1.0305	0.9999	1.0134	2.3287	0.4816
" A. R.....	1.0366	1.02	.....	0.9458	1.0578	1.00006	0.9673	0.9843	1.0508	1.0195	1.0334	2.3745	0.4911
" Chili	1.0961	1.078	1.0574	.....	1.1375	1.0574	1.0228	1.0408	1.1111	1.0780	1.0927	2.5107	0.5194
" Uruguay	0.9636	0.9479	0.9295	0.8971	.....	0.9296	0.8992	0.9510	0.9768	0.9477	0.9606	2.2073	0.4564
" Ven.....	1.0365	1.0916	0.9999	0.9457	1.0757	.....	0.9673	0.9843	1.0508	1.0194	1.0333	2.3744	0.4909
" Bolivia..	1.076	1.0541	1.0338	0.9777	1.1121	1.0338	.....	1.0130	1.0864	1.0503	1.0683	2.4548	0.5077
" Ecuador	1.0539	1.033	1.016	0.9608	1.0929	1.0114	0.9600	.....	1.0676	1.0357	1.0496	2.4123	0.4989
" Nfld.....	0.9864	0.9703	0.9516	0.9	1.0203	0.9517	0.9205	0.9367	.....	0.9701	0.9834	2.2979	0.4673
" P. I.....	1.0168	1.0002	0.9809	0.9277	1.0552	0.9809	0.9488	0.9655	1.0308	.....	1.0136	2.3291	0.4817
Yen.....	1.003	0.9867	0.9677	0.9152	1.041	0.9677	0.9361	0.9525	1.0165	0.9865	.....	2.2978	0.4752
Toman	0.4366	0.4294	0.4211	0.3983	0.4528	0.4209	0.4074	0.4145	0.4435	0.4293	0.4352	.....	0.2068
Rupee	2.1109	2.0765	2.04	1.926	2.1907	2.0365	1.9700	2.0045	2.1400	2.0760	2.1044	4.8356	.....
Piastre, Tunis.	8.5646	8.425	8.2623	7.14	8.8883	8.2628	7.9923	8.1329	8.6825	8.4234	8.5383	19.619	4.0573
" Egypt.	20.074	19.832	19.366	18.315	20.8332	19.367	18.7231	19.0625	20.394	19.7434	20.059	45.9933	9.5100
" Turkey	22.763	22.3928	21.9598	20.7685	23.6237	21.9611	21.2424	21.6158	23.0765	22.388	22.6932	52.144	10.7835

*From *The World's Metal Monetary Systems*, by John Henry Norman, 1892.

The decrease shown in 1894 from 1893 was to some extent compensated for by shipments from San Francisco directly to China and Japan. During the latter part of that year arrangements were made by which silver could be transmitted directly to the East at a lower cost than by way of London, and a large amount will doubtless find its way by that route, although much of the silver will still seek the central market as long as London holds that position.

WEIGHTS OF GOLD AND SILVER COINS.*

Table of weights of gold and silver coins on issue from the mints. These coins are, or should be, current in the World's present twenty-nine monetary systems. Col. I.—Pure gold or pure silver in 1000 parts of metal. Col. II.—Proportion of silver to 1 of gold between the weights of both indicated by one money of account under mintage regulations. Col. III.—Names of the coins. Col. IV.—Total weight and weight of pure gold (G.) and pure silver (S.) in grams. Col. V.—Total weight and weight of pure gold and pure silver in Troy grains.

Col. I.	Col. II.	Col. III.	Col. IV.—Grams.		Col. V.—Grains.	
			Total Weight	Weight of Pure Metal.	Total Weight	Weight of Pure Metal.
875.	15.	Egyptian pound	G 8.5000	7.4375	131.1749	114.7781
900.	.....	10 piasters	S 12.5000	11.25000	192.9043	173.6139
916.667	14.287	British pound	G 7.9881	7.3224	123.2740	113.0016
925.	.....	1 shilling	S 5.6552	5.2310	87.2250	80.72937
916.667	15.1	Turkish pound	G 7.216	6.6147	111.3598	102 0804
830.	.....	20 piasters	S 24.055	19.9650	371.2313	308.1168
916.667	14.09	Portuguese 5-milreis	G 8.8675	8.1285	136.8460	125.4425
916.667	.....	5 testoons	S 12.5000	11.4583	192.9043	176.8284
917.	14.4	Uruguay 5-peso	G 8.4850	7.7807	130.9435	120.0750
900.	15.5	1 peso	S 25.0000	22.5000	385.2087	347.2278
916.667	14.3	Newfoundland 2-dollars	G 3.3280	3.0507	51.35886	47.07895
925.	.....	50 cents	S 11.7820	10.8983	181.8234	168.1871
900.	16.	United States 5-dollars	G 8.3591	7.5232	129.0000	116.09985
900.	.....	1 dollar	S 26.7290	24.0567	412.5000	371.2514
900.	15.5	Argentine Republic 5-dollars	G 8.0645	7.25805	124.5415	112.00875
900.	.....	1 dollar or peso	S 25.0000	22.5000	385.2087	347.2278
.....	.....	Cuba 1-peso	G	1.3933	.....	21.5019
900.	16.39	Chile 5-pesos	G 7.6265	6.8639	117.6941	105.92533
900.	.....	1 peso	S 25.0000	22.5000	385.2087	347.2278
916.667	14.22	Brazil milreis	G 8.9648	8.2178	138.34793	126.81996
916.667	.....	2 milreis	S 25.5000	23.3750	393.5249	360.7311
983.	15.6	Netherlands 10-guilders	G 6.729	6.0561	103.84428	93.45985
945.	.....	1 guilder or florin	S 10.0000	9.4500	154.3235	145.8357
900.	14.88	Danish 20-crowns	G 8.9606	8.0645	138.2831	124.45418
800.	.....	2 crowns	S 15.0000	12.0000	231.4852	185.1882
900.	13.95	German 20-marks	G 7.965	7.16846	122.917896	110.626801
900.	.....	1 mark	S 5.5555	5.0000	85.7359	77.1617
900.	15.5	French 20-francs	G 6.4516	5.8065	99.56334	89.60701
900.	.....	1 franc	S 5.0000	4.5000	77.0417	69.4455
A weight	No coin	Shanghai tael	S	33.2457	.....	513.0607
900.	.....	Trade dollar	S 27.2156	24.4940	420.0000	378.0000
902.778	16.	Mexican dollar	S 27.0643	24.4330	417.6657	377.0586
875.	.....	16 pesos	G 27.0643	23.6813	417.6657	365.45753
.....	.....	Java dollar or 2½-guilders	S 28.0785	24.3737	433.3172	376.1434
900.	16.173	Japan 1-yen	S 26.9564	24.2607	416.0000	374.4000
.....	.....	5 yens	G 8.33335	7.5000	128.60317	115.74262
900.	15.79	Philippine dollar	S 25.9600	23.3640	400.6253	360.5614
875.	.....	1 peso	G 1.6915	1.4796	26.0961	22.83705
900.	15.5	Peruvian sol	S 25.0000	22.5000	385.2087	347.2278
.....	.....	10 sols	G 16.1290	14.5161	248.90837	224.01753
.....	.....	Tripoli mahbub	S	20.2957	.....	313.2101
868.056	15.	Russian rouble	S 19.9957	17.9961	308.5806	277.7221
916.667	.....	5 roubles	G 6.5440	5.9987	101.0000	92.57403
910.	.....	Siamese tical	S 15.1805	13.3670	234.2711	206.2850
900.	15.3	Austrian florin	S 12.3457	11.1111	190.5231	171.4703
900.	.....	8 florins	G 6.4516	5.8065	99.563349	89.60701
916.667	15.	Indian rupee	S 11.6638	10.6918	180.0000	165.0000
916.667	.....	15 rupees	G 11.6638	10.6918	180.0000	165.0000
900.	13.37	Persian kran	S 4.5861	4.0843	70.7740	63.0316
990.	.....	1 thoman	G 3.4667	3.4321	53.49032	52.96536
900.	15.86	Tunis 1-piaster	S 3.0970	2.7875	47.7939	43.0145
900.	.....	50 piasters	G 9.7600	8.7840	150.61973	135.55776

* From *The World's Metal Monetary Systems*, by John Henry Norman, 1892.

PRODUCTION OF GOLD AND SILVER FOR FOUR CENTURIES—THEIR COST, USES IN MONEY AND LOGICAL RATIO OF VALUES.

The relative production of gold and silver and the actual production of gold are the most important questions in the mineral industry to-day, for on them depend the stability of the world's money and, in a measure, the prosperity of a large part of the human race.

The search for gold is universal, and every country is increasing its output, no doubt because the increased demand for gold, like increased demand for anything else of which there has been no overproduction or surplus on the market, has increased its market value or purchasing power. How far the output of the yellow metal may be increased is uncertain; the greater part of that won in the United States is obtained from ore, and its increase must therefore be comparatively slow, but it will doubtless go on for many years to come.

The demand for gold and silver has always been due to their use in money; the uses in the industries, chiefly as ornaments and articles of luxury, are due rather to the fact that the metals are used in, and are easily convertible into, money than to their intrinsic physical properties, so that it may be said almost the entire demand for both gold and silver has always been on account of their use in money. It is because their possession is an evidence of wealth, and brings to their possessor the consideration and homage of his fellows, that there is a demand for them, and not because their physical properties are so superior to those of many other metals as to justify the difference in their prices. There is not now and never will be any large use in the industries dependent upon the intrinsic properties of either gold or silver that would give it a value at all comparable with its present price, or that would induce its production in large amounts.

It is evident from their writings that most of those who discuss the question of the money uses of gold and silver are not familiar with the conditions under which these metals are found in nature, nor with the methods adopted in winning them from their ores.

THE ACTUAL AND RELATIVE PRODUCTION OF GOLD AND SILVER.

The world's stock of gold and silver was exceedingly small when America was discovered in 1492. Chevalier estimates the stock in Europe at that time at only $193,000,000. It was greater in Asia, where some authorities conjecture that it may have been $1,500,000,000.* These estimates are probably greatly exaggerated.

It is extremely unlikely that, during the 1500 years of the Christian era preceding the discovery of America, the world's production of gold averaged 1000 kilos a year, or of silver 8000 kilos, or after allowing for losses of the metals, that the total stocks of gold and silver in the world in 1492 amounted to 1,000,000 kilos gold and 8,000,000 kilos silver, or say $1,000,000,000.

The following table is taken from Dr. Adolph Soetbeer's "Materials Toward the Elucidation of the Economic Conditions Affecting the Precious Metals, for years 1793 to 1850," and completed to 1894 from the reports of the United States Mint and other reliable sources:

* Report of Silver Commission, 1877, p. 8.

WORLD'S PRODUCTION OF GOLD AND SILVER SINCE THE DISCOVERY OF AMERICA—1492.

(1 kilo gold = $664.60.)

Period.	Gold.				Silver.			Weight Ratio of Silver to Gold.	Value Ratio Gold to Silver
	No. of Years	Production.			Production.		Total Commercial Value.		
		Annual.	Total.	Total Value.	Annual.	Total.			
		Kilos.	Kilos.		Kilos.	Kilos.			
1493–1520...	28	5,800	162,400	$107,836,848	47,000	$1,316,000	$81,434,080	8.1	10.75
1521–1544...	24	7,160	170,400	114,102,912	90,200	2,164,000	138,015,440	12.6	11.25
1545–1560...	16	8,510	136,160	87,305,536	311,600	4,985,600	293,510,720	36.6	11.30
1561–1580...	20	6,840	136,800	90,835,080	299,500	5,990,000	346,428,040	43.8	11.50
1581–1600...	20	7,380	147,600	96,870,400	418,900	8,378,000	470,573,600	56.8	11.80
1601–1620...	20	8,520	170,400	113,149,960	422,900	8,458,000	459,963,960	49.6	12.25
1621–1640...	20	8,300	166,000	110,227,320	393,600	7,872,000	372,831,760	47.4	14.00
1641–1660...	20	8,770	175,400	116,467,680	366,300	7,326,000	344,770,800	41.8	14.50
1661–1680...	20	9,260	185,200	122,974,600	337,000	6,740,000	298,366,320	36.4	15.00
1681–1700...	20	10,765	215,300	142,961,844	341,900	6,838,000	302,702,680	31.8	14.97
1701–1720...	20	12,820	256,400	167,875,680	355,600	7,112,000	309,757,000	27.7	15.21
1721–1740...	20	19,080	381,600	253,389,080	431,200	8,624,000	380,666,720	22.6	15.08
1741–1760...	20	24,610	492,200	326,831,120	533,145	10,662,900	479,636,640	21.7	14.75
1761–1780...	20	20,705	414,100	275,970,920	652,740	13,054,800	590,339,960	31.5	14.73
1781–1800...	20	17,790	355,800	236,257,840	879,060	17,581,200	774,099,760	49.4	15.09
1801–1810...	10	17,778	177,780	118,048,000	894,150	8,941,500	380,926,140	50.3	15.61
1811–1820...	10	11,445	114,450	75,998,160	540,770	5,407,700	231,666,820	47.2	15.51
1821–1830...	10	14,216	142,160	94,397,940	460,560	4,605,600	194,015,220	32.4	15.80
1831–1840...	10	20,289	202,890	135,722,280	596,450	5,964,500	251,261,360	29.4	15.75
1841–1850...	10	54,759	547,590	363,609,260	780,415	7,804,150	326,900,140	14.3	15.83

Year.	Gold.		Silver.		Weight Ratio Silver to Gold.	Value Ratio Silver to Gold.
	Kilos.	Value.	Kilos.	Commercial Value.		
1851	107,153	$67,600,000	875,600	$37,651,000	8.1	15.46
1852	198,315	132,800,000	888,735	37,688,000	4.5	15.59
1853	233,975	155,500,000	888,735	38,509,000	3.9	15.33
1854	191,845	127,500,000	888,735	38,509,000	4.5	15.33
1855	203,280	135,100,000	888,735	38,393,000	4.4	15.38
1856	222,013	147,600,000	904,270	39,073,500	4.1	15.38
1857	200,572	133,300,000	904,270	39,355,000	4.5	15.27
1858	187,632	124,700,000	904,270	39,073,500	4.9	15.38
1859	187,933	124,900,000	906,490	40,722,400	4.9	15.19
1860	164,460	119,300,000	906,490	39,459,500	5.5	15.29
1861	171,215	113,800,000	1,013,617	43,474,200	6.0	15.50
1862	162,228	107,800,000	1,025,955	43,423,800	6.4	15.35
1863	160,999	107,000,000	1,105,659	47,864,500	6.9	15.37
1864	170,027	113,000,000	1,172,349	50,645,500	6.9	15.37
1865	180,860	120,200,000	1,189,152	51,182,100	6.6	15.44
1866	182,215	121,000,000	1,357,477	58,411,200	7.4	15.43
1867	156,485	104,000,000	1,448,332	61,843,800	9.3	15.57
1868	165,062	109,700,000	1,341,444	57,145,300	8.1	15.59
1869	159,795	106,200,000	1,269,295	54,071,700	8.0	15.60
1870	160,848	106,900,000	1,378,855	58,876,100	8.6	15.57
1871	160,999	107,000,000	1,903,998	81,300,700	11.8	15.57
1872	149,849	99,600,000	2,034,852	86,521,800	13.5	15.63
1873	144,487	96,200,000	1,967,683	82,120,000	13.6	15.92
1874	136,090	90,800,000	1,719,901	90,673,000	12.4	16.17
1875	146,704	97,500,000	1,939,539	77,578,000	13.2	16.59
1876	156,034	103,700,000	2,107,210	78,322,000	13.5	17.88
1877	171,532	114,000,000	2,174,619	75,240,000	12.7	17.22
1878	179,055	119,000,000	2,326,432	84,644,000	13.0	17.94
1879	164,008	109,000,000	2,174,531	83,383,000	12.6	18.40
1880	160,397	106,600,000	2,322,999	85,636,000	14.5	18.05
1881	154,980	103,000,000	2,453,581	89,777,000	16.0	18.16
1882	153,626	102,000,000	2,690,109	98,230,000	17.5	18.19
1883	143,575	95,400,000	2,774,227	98,986,000	19.2	18.64
1884	153,039	101,700,000	2,537,564	90,817,000	16.6	18.57
1885	163,105	108,400,000	2,841,572	97,564,000	17.4	19.41
1886	159,509	106,000,000	2,896,882	92,772,000	18.1	20.78
1887	159,156	105,775,000	2,992,451	94,031,000	19.0	21.13
1888	165,659	110,197,000	3,424,771	102,283,000	20.6	21.99
1889	185,809	123,489,000	3,901,809	112,399,700	20.9	22.10
1890	178,825	118,848,700	4,180,532	132,399,700	23.3	19.76
1891	196,586	130,650,000	4,267,380	135,524,800	21.6	20.92
1892	220,133	146,297,600	4,757,955	133,822,600	21.6	23.72
1893	256,236	158,437,551	5,339,746	134,241,121	20.9	26.43
1894	293,542	179,345,704	5,205,065	105,429,034	17.9	32.81
Total	12,470.477	$8,261,673,015	242,019,823	$10,266,884,715	19.4	16.18
At U. S. coining value	.....	.....	.....	10,058,343,843	.....	16.00

(*a*) For the period 1501–20; (*b*) 1521–40; (*c*) 1541–60.

NOTE.—The figures from 1493–1850, both years inclusive, are Soetbeer's; those for 1811–51 are from the reports of the Director of the Mint; those for 1892–94 are from direct returns of United States refiners, made to the *Engineering and Mining Journal.*

Approximately accurate statistics of production of the metals have been compiled only since the discovery of America, and the figures here quoted would make the aggregate output of the precious metals in the world since that date up to the end of 1894 to have been 12,470,477 kilos gold and 242,019,823 kilos silver, or, in other words, the total production of the world since 1492 to the present time has been by weight in the proportion of 19.4 silver to 1 gold, and in commercial value 16.18 silver to 1 gold. This production may fairly be considered as representing roughly, but with as great accuracy as can be secured by any other means, the average relative cost of producing these metals.

These statistics show in the clearest manner that there has been from very early times a certain, though not uniform, increase in the value of gold as compared with that of silver; or otherwise a slight, though irregular, depreciation in the value of silver as compared with gold, and, emphatically, that the actual and relative production of silver was independent of its commercial value.

In the twenty-eight years from 1493 to 1520 the production of silver averaged by weight 8.1 times that of gold, while it required 10¾ of silver to equal 1 of gold in value. The production of gold grew but very slowly during the 107 years from 1493 to 1600, while that of silver increased about 700%, its output averaging in the twenty years ending with 1600 no less than 56.8 times that of gold, though its relative value declined only about 10%, or to a ratio of 11.8 to 1 gold. During the next century the output of silver actually declined, while that of gold increased. The relative weights averaged, from 1680 to 1700, about 31.8 silver to 1 gold, or nearly double the proportion in which the metals are at present produced, yet while it then required only 15 of silver to equal 1 of gold in value, it required in 1894 no less than 32.81 silver to equal 1 of gold.

During the 170 years from 1700 to 1870 the relative values of gold and silver varied only between the limits of 14¼ and 16¼ to 1 (which represented about the average coining ratios), though the production ratio fluctuated between the limits of 4 and 50 silver to 1 gold. Thus from 1700 to 1720 the production was, by weight, about 28 silver to 1 gold; 100 years later, in 1800 to 1810, it averaged 50.3 silver to 1 gold, and 50 years later, or from 1850 to 1860, it averaged only 4½ silver to 1 gold.

It is evident, therefore, that while the commercial value of silver, as compared with that of gold, remained nearly stationary for more than 250 years the actual and relative production of the metals varied greatly. During all those years the production of silver was not controlled by its market value, but rather by the discovery of bonanzas, and the large investments in mining which these gave rise to. The market or demand was then so wide it absorbed all that was produced, and there was no unwanted surplus to depress the price.

Germany, in December, 1871, assumed the sovereign right of coinage, adopted the gold standard and discontinued the free mintage of silver, and in July, 1873, it commenced the sale of its silver, and thereby forced France, and in the following year the whole Latin Union, to limit its coinage of silver. In February, 1873, the United States, which had then no silver money in circulation, reduced the legal-tender right of silver to payments not exceeding $5; thus practically demonetizing it. In 1874 the Scandinavian States demonetized silver, and in 1875 and 1876 Holland, Switzerland, Belgium, France, Spain and Russia sus-

pended the mintage of silver, except in special cases for government account. In June, 1893, India closed her mints to free coinage, and in October the United States ceased the heavy purchases of silver which had been continued from 1878 and had aggregated no less than 459,946,701 oz. of silver. The growing amount of this stock created great anxiety in Europe, and no doubt induced several other countries to close their mints to silver, of which they feared the letting loose of a deluge by the United States. So long as nearly all the great commercial nations kept their mints open to free coinage the world's production of silver was readily absorbed without any greater fluctuation in its price than was to be expected from the different ratios adopted by different countries, but when those nations closed their mints the price of silver at once declined, without any such disproportionate production of silver as had frequently existed in the past, and notwithstanding the very large purchases by the United States.

It is evident from these statistics, and may be deemed absolutely certain, that the opening of the mints of all the chief commercial nations to free coinage, or in other words the adoption by them of bimetallism, would create a market so wide that all the silver produced would be readily absorbed at the value ratio adopted, and that there would be no danger of overproduction. It is equally certain that no one or two countries, and perhaps not even three countries, could alone or together make a market wide enough to do this.

While these statistics show that the great fluctuations in production did not affect, and were not due to, changes in the value of silver or gold, yet it is undoubtedly true as a general proposition that the actual and relative amounts of gold and silver produced will always depend :

1. On their actual abundance in nature ;
2. On the relative profits derived from their production.

If it pays better to produce silver than to produce gold at their current exchangeable values, capital will inevitably seek investment in silver rather than in gold mines, and the production of silver will increase more rapidly than that of gold. Or if the production of one metal is found, over a period of years, to be increasing more rapidly than that of the other, it is a demonstration that at the then market values of the metals it pays better to produce it. If this condition should continue indefinitely it is evident that in the course of time there would be such an excessive amount of the one that the stock of the other would be insufficient to form a safe reserve for redemption of it. Nature has, however, provided a regulator of production in the limited amount of either metal found in any one deposit and in rarity of large deposits, and the complete control of this condition and the absolute prevention of any dangerous overproduction of either metal would be assured by making, when necessary, small changes in the value ratio of the metals. It is evident changes in ratio would very rarely be required.

To emphasize these lessons of the statistics we may reiterate that during the 200 years from 1492 to 1693 the world's production of gold never reached 10,000 kilos in one year, and during the next 155 years, from 1693 to 1848, that is, until the discovery of gold in California, the total yearly output of the yellow metal never attained 30,000 kilos; it becomes quite apparent how very scarce the metal is in nature, and how small an increase in either silver or gold output would, at that time, have materially changed their production ratio.

It was not until the Spanish conquest of Mexico, Peru and Bolivia (1520–40) that the whole output of silver in the world amounted to 100,000 kilos a year, but with the opening of these countries and the great impetus it gave to the search for silver, and with improvements in metallurgical processes, the annual production quickly rose to 300,000 and even reached 423,000 kilos about the year 1600, the production ratio of silver to gold being then nearly 57 to 1, the greatest it has ever attained.

For the next 100 years the output of silver declined somewhat, while that of gold increased from an annual output of about 8000 kilos to as much as 25,000 kilos, a veritable "boom" in gold mining having followed the discovery of rich placers in 1695 in Brazil, and in 1737–45 in Russia. These bonanzas were quickly exhausted even by the crude mining methods of those early days, for the annual output of gold declined steadily during the next 50 years, from 1760 to 1810, at which latter date it was averaging about 11,500 kilos a year.

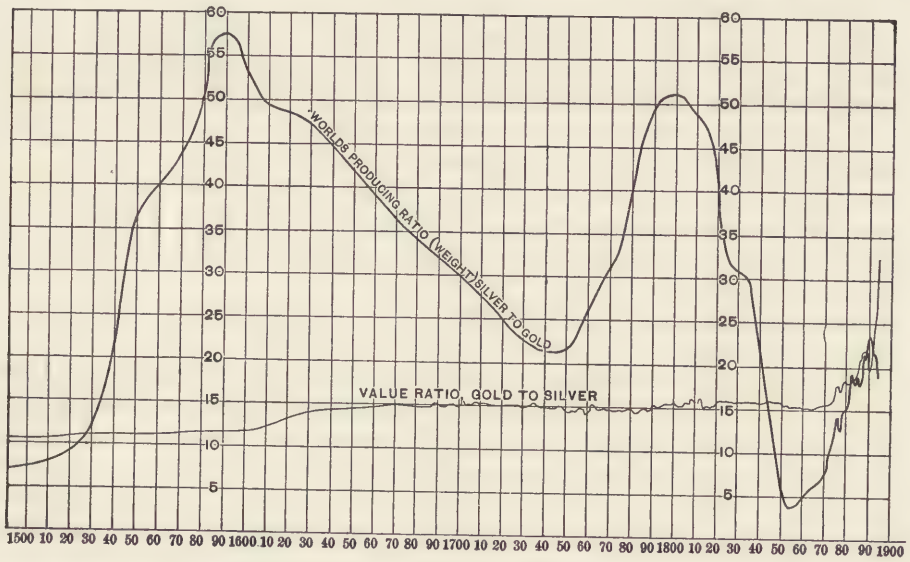


DIAGRAM SHOWING FLUCTUATIONS IN PRODUCTION AND VALUE RATIOS OF SILVER AND GOLD SINCE 1492.

The production of silver increased as that of gold declined. From 1750, when the average yearly silver output was about 530,000 kilos, it rose until in 1800–10 it averaged nearly 900,000 kilos a year, reaching a production ratio of 50 to 1 of gold. That silver "boom" then collapsed and the output declined, while that of gold increased.

The great California placers, discovered in 1848, and those of Australia, found in 1851, jumped the yearly output of gold up from about 30,000 kilos to 200,000 kilos, and brought the production ratio of silver to gold down, in ten years, from about 16 to 1 in 1848 to 4 to 1 in 1860.

In 1860 this gold tide began to ebb, notwithstanding the immense output of gold as well as silver from the Comstock mines, and it reached its minimum in 1883 when the world's output was nearly 144,750 kilos of gold; since then it has

steadily, and since 1890 rapidly, increased. The world's production of silver continued to increase until 1893, but has now passed its maximum for this wave, at 5,339,746 kilos, and will undoubtedly decrease for some years to come. The present production ratio is 17.9 silver to 1 gold, or less than the average proportion, 19.4, in which the metals have been produced since the discovery of America in 1492.

It is also very noteworthy that the average commercial value of the total of silver produced since 1492 to the close of 1894 has been almost identical with the United States coining ratio, or 16.18 silver to 1 gold, as compared with 16 to 1, and it is certain that another year will see this ratio below 16 to 1.

The most notable facts brought out into strong relief in these statistics, and explained in the chronology of the gold and silver industry, are:

(*a*) The smallness of the amounts of gold and silver produced in all ages.

(*b*) The fluctuations in actual, and relative, quantities of the metals produced, showing waves of production, first of one metal and then of the other.

The history of mining has afforded a full explanation of these notable facts. Gold and silver are found in nature in only very limited quantities. Deposits of unusual richness, called bonanzas, are rare and are quickly worked out with modern methods and appliances. The early gold bonanzas which affected the world's rate of production were placers, which yielded their gold in large amounts easily and with great profit. They were exhausted with comparative quickness even in those days; now, even under the growth of the metallurgist's art, the production of gold, which is chiefly from its ores, increases more slowly, though more uniformly, than from the gravels of former days. Silver has always been obtained chiefly from its ores by metallurgical treatment, but as attention and capital were directed to its production, bonanzas were discovered and improvements were made in mining and metallurgy which largely increased its output.

Profit is now, and has always been, the sole incentive to the discovery of mines and of improvements in methods of winning the precious metals. We may therefore conclude that effects which are now due to this cause can be explained in the same manner when they occurred in other ages. The discovery and working of an unusually rich deposit of either metal results in enormous gains to those who own it. These abnormal profits are quickly made public, especially in modern newspaper times, and labor and capital are attracted in the perennial hope of finding similar riches and profits. The search thus inaugurated results usually in the discovery of many productive mines which add largely to the output, while much the larger part of the capital is lost in misdirected efforts, or in simple gambling. Thus a general disgust with investments in mining that particular metal follows, capital is withdrawn from it, and labor, being unable to find occupation in it, turns to exploring deposits of the other metal, which is not then in discredit, and bonanzas of that are in turn uncovered.

The output of the discredited metal continues large for some time after public interest has left it, because the rich mines continue to yield large amounts while being exhausted and, consequently, the turning point of production always follows, and is never coincident with the change in public interest.

In the case of silver in recent years, the decline in the market value of the

metal hastened the ebb of the silver wave by increasing the losses of capital invested in unprofitable silver mines, and, at the same time, stimulated a universal demand for gold.

Moreover the discovery of the South African and West Australian gold fields has afforded a foundation on which skillful promoters have built a wide public interest in gold production at the expense of silver mining. The tide in gold mining is rising, and it promises to do so for many years to come. With the increase in gold output the cost of the annual production of a given large amount of the metal is declining, partly by reason of improved methods of winning it, and partly because the bonanzas now being worked are, for the most part, new and still increasing in output. On the other hand the production of silver is declining and the average cost of producing a large amount of it (say 5,000,000 kilos a year) is increasing as the bonanza mines are being exhausted.

The tide of silver production would certainly have turned before many years, even had the value of the metal been maintained at its coinage rate, for the simple reason that vast amounts of money had been lost in silver mining.

The great gold-mining boom which followed the discovery of the placers of California, Australia and Russia, attracted labor and capital from every part of the world. The output of the metal became so large that its purchasing power declined from 9% to 15%, according to Jevons, and induced Holland to adopt the single silver standard, and some other countries to adopt bimetallism. The great disparity in production between gold and silver at that time alarmed the whole financial world and violently disturbed values. These fluctuations led far-seeing economists to seek, through the adoption of universal bimetallism at a fixed value ratio between the metals, to equalize and steady the supply of the money metals, for the fluctuations in the sum of the two metals are much less than in the output of either alone. In the early ages when the accumulated stocks of gold and silver were comparatively small these waves of production greatly changed the production ratio. As stocks accumulate the output of any bonanza becomes relatively less important as a disturbing factor, and the increase in knowledge tends to lessen the length and height of the waves of investment and of relative production.

THE COST OF PRODUCING GOLD AND SILVER.

If investments were made in gold and silver mining with the prudence which characterizes those in most other branches of industry, instead of being, as they are in the majority of cases, simply gambles in a lottery, it would be possible to determine with a fair degree of accuracy the relative cost of producing the metals in any given quantity, and we would then have a logical ratio of values for their use in money. Unfortunately the problem is not so simple and cannot be solved with mathematical exactness.

It is not, of course, proper to consider the gambling investments in worthless mines and stocks as a charge against the gold and silver produced; still the actual legitimate cost of producing varies so greatly with the grade and amount of the ore and the facilities for mining and treating it, and these conditions are themselves so variable that even the actual expenditure in producing the total output of either metal one year would not be a fair measure of that in other

years. Nevertheless such facts are valuable aids in arriving at the approximate average cost of production.

In THE MINERAL INDUSTRY, Vol. I., the cost of producing 17,757,025 oz. of silver, or 32½% of the United States production in 1890, was ascertained to have been, exclusive of interest on capital invested, 50.6c. per oz., and it was estimated that of the 65,000,000 oz. produced in 1892 one-half was produced probably at an average cost of 65c. and one-half at 90c., giving an average for the whole of 77.5c. per oz.

It is certain that the mines which produced nearly 18,000,000 oz. in 1890 at a cost of 50.6c. per oz. could not now do so, notwithstanding the decline in wages and in many items of cost that have since taken place; because most of these mines are no longer in bonanza, and the grade of the ore has declined more rapidly than the costs of treating it.

In any inquiry as to the average cost of producing the precious metals the amount to be produced is an essential element in the problem. Probably more than 5,000,000 oz. are produced annually in the United States as a by-product in getting other metals, but if 65,000,000 oz. a year were now suddenly required it certainly could not be produced at 77.5c. per oz. Further than this the cost of producing such an amount in a year is increasing and will continue to increase until new bonanzas are found, and there is now little inducement to expend money in the costly search for these.

The commercial value of silver at the turning point when capital abandoned its production and sought that of gold would afford an approximate relative average cost of producing the two metals, though even this measure would be far from strictly accurate.

If we find that the production ratio of silver to gold over a long series of years has not greatly differed from their commercial value ratio then we can conclude with a fair degree of accuracy that the profits on their production have not greatly differed; that is, that their relative cost has been about the same as their production ratio, for we assume as absolutely true that capital will go into the production of that which pays the best, taking due account of the risks in the business.

While a gold bonanza, owing to the higher value of the metal, is, probably, more profitable than one of silver, yet the risks are greater. It may indeed be stated, as a general proposition, with an approximation to the truth, that the profits in producing any of the metals is, in a rough way, inversely proportional to the unit value of the metal itself. No doubt, on the whole, the producing of silver is a more profitable investment for capital than that of gold, as the production of copper is more profitable than that of silver. It is probably also true that on the whole much more money is lost in the production of gold than in that of silver.

If either of the metals could be produced at anything like the small cost which the secular writers, who are unacquainted with the technology of the industry, are so fond of asserting, capital would be much more eager to invest in the industry and the output of the precious metals would be greatly increased.

Now the total production of the world since 1492 amounted to 12,470,477 kilos gold and 242,019,823 kilos silver, or in the proportion of 19.4 silver to 1

gold. Taking the values of the metals at their current value ratios throughout that period, as given in the accompanying table, the average relative values of this gold and silver were as 16.18 to 1—that is, assuming gold to be worth $20.67 per oz. troy, or $664.60 per kilo, the value of the silver would be $1.27 per oz. The average relative cost of producing the metals in the last 402 years may be counted as between the average production and value ratios, that is to say, between 16.18 and 19.4 to 1 and a reasonable ratio for coinage at the present time would, considering the trend of the ratio value, be perhaps 18 to 1. For a series of years to come a ratio of 16 to 1 could undoubtedly be maintained under universal bimetallism without any dangerous overproduction of silver, for, as already explained, during the next decade the relative cost of producing gold and silver will probably be much below 16 or even 15½ to 1.

The late Dr. Soetbeer suggested as a fixed ratio for universal bimetallism 20 to 1 ($1.03 per oz. for silver), and this is a proportion which would over a long series of years favor the production of gold.

THE SUPPLY OF THE PRECIOUS METALS FOR USE IN MONEY.

It must not be supposed that the entire production of gold and silver is available for use in money, for a large part of each, and especially of gold, is at present used industrially. Estimates made by Humboldt in 1827, from direct returns of some of the manufacturers, were that one-fifth of the production was so used, while Lowe estimated it in 1822 at two-thirds of the production. Dr. Soetbeer endeavored at different times to ascertain the amount of gold and silver used industrially, and his latest estimate, in 1891, was 650,000 to 750,000 kilos silver as so used in Europe and the United States alone. He estimated the consumption of gold in industry and for export to India, and amount hoarded, to have been 120,000 kilos out of an average production of 160,000 kilos, leaving but 25% available for "increase of the active monetary gold stock of civilized countries." The director of the United States Mint has estimated, from direct returns of manufacturers, that the United States and Europe alone consumed in 1892–93 75,500 kilos gold, or about 33% of the world's production, and 663,000 kilos of silver, equal to 13.37% of the world's production, and this without counting the largest consumers—India, China and the Straits.

All statisticians agree that the industrial consumption of gold is increasing, with increasing wealth, more rapidly than that of silver, which will probably decline as the value of the metal declines and its use in money is discontinued.

The world's coinage, according to the director of the United States Mint, amounted in 1891, 1892 and 1893 to the following sums:

	Gold.	Silver.
1891.....	$119,534,122	$138,294,367
1892.....	172,473,124	155,929,765
1893.....	231,862,530	135,945,426

This amount includes also the recoinages and use of old material, so that the new metal going into coinage is much less than this. Since coins, new and old, are melted down for use in industry, even if we knew the amount of recoinages and

of foreign coins melted down at the various mints for recoinage, it would by no means enable us to determine the amount of gold and silver annually added to the world's stock of money. There appears to be only one way in which this can be done with any degree of accuracy, namely, by ascertaining the actual stock of gold and silver used as money in the different countries, and from year to year. The United States Mint published in 1894 an estimate of the stock of gold and silver money in the world, which gave gold as $3,965,900,000 and silver $4,055,700,000. If we compare this with the total production of the metals since 1492, as given above (adding the amount of $1,000,000,000 we have estimated as the possible stock on hand in 1492), we find that the actual stock of gold money in the world now amounts to about 45% of the production, and that of silver to about 40% of the output. In other words, 55% of all the gold and 60% of all the silver produced in the last one thousand years has been used industrially, or been lost, and only 45% and 40% respectively have remained in money. At the present time it is certain that the annual addition to the gold money of the world is much less than 45%, and is probably not much above Soetbeer's estimate of 25% of the annual output of the metal. In other words, if the present enormous annual production of gold in the world be $180,000,000, the increase of the world's stock of gold money probably does not exceed $45,000,000 to $50,000,000 a year, or an annual increase of less than 1¼% of the gold alone, and about one-half of one per cent. of the existing gold and silver money combined. The annual increase in the war funds—all of gold—of a few European countries more than absorbs this small available increase in gold money.

The general demonetization of silver is rapidly reducing the international money of the world by one-half, or 50%, and is rendering suddenly the other half, the gold, with its annual increase of less than 1¼%, the sole money foundation for the commercial credits and business of the world.

Is it strange then that every new demand for any important quantity of gold, such as that to satisfy the Franco-German war indemnity; that for the resumption of gold payments by Austria; the recent United States loans, and even smaller transactions, should put the whole financial world in a tremor of anxiety? The fact that it is quite within the power of a number of individuals, acting singly or in combinations of two or three, to create such a demand for gold as would disturb the whole commercial world, owing to the small amount available for money and the increasing demands on that, must make it clear that the money of the world is in a very unsatisfactory and dangerous condition and calls urgently for intelligent international control.

Under these conditions would it be surprising if gold should appreciate in purchasing power—would it not rather be marvelous, and contrary to the universal law of supply and demand, if it did not?

We may sum up the evidence as follows:

The values or purchasing powers of gold and silver, as of everything else, depend solely upon supply and demand. The demand for them is chiefly for their use in coinage, the uses in the arts depending upon the estimation in which they are held, owing to their money values. The physical properties of the

metals would never create a demand for either, except for coinage, at any value which would secure its production in large quantity.

The manner of occurrence of gold and silver in nature precludes the possibility of their cheap production in large quantity. The cost of production of each, will, in the great majority of cases, always approach very nearly to its market value over a series of years, and, a large amount of each metal, and especially of gold, will always be produced at an actual loss.

While, generally, the higher the market value of either metal the more of it will be produced, yet on account of the discovery of great bonanzas there have always been, and always will be, waves of investment in and production of, first one, and then the other, of these metals.

Since profits in mining are, roughly, in inverse proportion to the unit value of the metal produced, and losses directly proportioned to this, the natural tendency from this cause, is for gold waves to be shorter in duration than silver waves, as indeed the statistics show they have been.

The more rapid spread of knowledge tends to lessen both the duration and the height of the waves of production, that is to say, it lessens the fluctuations in production ratio between the metals and at the same time makes the increase in aggregate production more uniform.

The fluctuations in production from year to year become altogether insignificant when compared with the world's total stock of the two metals.

As the metal appreciates in value more of it will be used industrially, and as it depreciates less will be so used—contrary to the rule with metals which are in demand for their physical properties alone.

Probably not more than 25% of the annual gold production is available as an increase in the stock of the money of civilized countries.

So long as the precious metals are used as the basis of the world's medium of exchange, the smaller the fluctuations and the more uniform the increase in the supply of this basis the less will be the disturbance in the world's industries.

There was no such production of silver in 1890–92, or since then, as to cause the slightest danger that silver would become so superabundant. There was no reason, in the actual or possible production of the precious metals, for the abandonment of bimetallism by Germany in 1871. That was due to a groundless belief that the actual or possible production of silver would endanger the free interchangeability of the metals under international bimetallism.

To assure absolute confidence in the future it is only necessary to place the control of the ratio between the metals in a permanent international monetary commission or clearing-house, which not only would dispel all anxiety concerning the stability and safety of universal bimetallism, but by the adoption of well-known clearing-house methods would render all the gold and silver money more readily available for the needs of the world.

The Amalgamation of Free-Milling Gold Ores.

By Louis Janin, Jr.*

INTRODUCTION.

Much has been produced by many writers on gold milling. Most of these have considered it a purely mechanical operation and have treated it as such. Doubtless they have been correct, as the most notable advancement has been made in the direction of mechanical improvement and the lessening of costs. The metallurgical features have been kept in the background, not because they do not exist, but because little attention has been paid to them. All experience has shown that losses may occur from many causes and that it is folly to suppose that a gold mill of any given type will work all gold ores successfully.

In this article mechanics have been made subordinate to metallurgy—that is to say, to the art of mining gold with the least possible loss and cost. Mechanical features have been only touched upon where they affect the economical or successful treatment of the ores. There are many excellent treatises extant on that branch of the subject which supply all needed information.

As it is clearly impossible and undesirable to write entirely from one's own experience on such a comprehensive division of metallurgy, the writings of other engineers have been drawn upon, but with due credit given in each instance. The writer, however, wishes to express his special indebtedness to the excellent series of articles on "The Variations in the Milling of Gold Ores," by T. A. Rickard, published in the *Engineering and Mining Journal* from time to time, to the thorough monograph on "Milling in the Black Hills," by H. O. Hofman, and to the no less elaborate treatise on "The Milling of Gold Ores in California," by John Hays Hammond.

LOSSES AND THEIR CAUSES.

Among the many reasons which have been formulated to account for the losses in milling by the free-milling gold process, the following seem most plausible and satisfactory :

1. The mechanically fine condition of the gold.
2. The mechanical association of the gold with minerals that may exert a prejudicial effect on amalgamation.
3. The chemical combination of the gold with other elements.
4. Improper construction of the plant.
5. Carelessness in manipulation. (*a*) Too fine crushing. (*b*) Too coarse crushing. (*c*) Foul, slimy or greasy battery water. (*d*) Impure mercury. (*e*) Crushing waste with the ore. (*f*) The use of excessive quantities of water.

The Mechanically Fine Condition of the Gold.—In most of our milling ores of medium grade little or no gold is visible to the eye. A large portion of the gold can be seen, however, by panning the sample down. In some ores, particularly those proven rebellious, no gold, or very little, and that extremely fine, can be

* [Owing to Mr. Janin's absence in Australia, this article has not received his personal revision, and some additions which he had intended making to it.—Ed. Mineral Industry.]

seen on panning. Microscopic examination in either case shows the wide dissemination of fine gold particles throughout the gangue. J. A. Edman* has made a series of microscopic investigations of many of our gold ores, and has found that a large proportion of the gold exists in particles less than $\frac{1}{250}$ in. in diameter. Moreover, a great proportion of the gold observed was less than $\frac{1}{1000}$ in. in diameter, and with powerful objectives the limit of diffusion was not reached at $\frac{1}{50000}$ in. A single chip of quartz $\frac{1}{50}$ in. in diameter under a magnifying power of 50 diameters showed over 300 gold particles, varying in size from $\frac{1}{1000}$ to $\frac{1}{12000}$ in., not only on the surface but diffused through the transparent mass. Higher powers showed still greater numbers of smaller particles. The late E. N. Riotte, in investigations of the Marmora, Ontario, Canada, auriferous arseno-pyrite,† claimed to have found that after all visible gold had been separated out with the aid of a microscope the pulp, in which no particles of free gold could be observed, still contained about $20 a ton. This Riotte considered "combined gold," but as gold in arseno-pyrite may safely be assumed to be in the metallic state, it was probably in such fine condition as to be practically invisible.

This fine condition of gold may occasion loss in several ways. In the first place the fine gold has a tendency to float on water, or at least to be carried in suspension by a current of water; secondly, the fine particles may not come in contact with the mercury or mercurialized copper plates. In fact, it may be said that it is in the treatment of this class of free-milling ores that the weakness of our present gold-milling system is shown.

An investigation of the waters of the Yuba River, California, is said to have shown, 20 miles below hydraulic operations, float quicksilver embracing particles of gold microscopically fine. Experiments made on the waste waters of the Eureka and Idaho mills, Grass Valley, Cal., showed that 20 gals. of water taken three-quarters of a mile below the mills contained on an average 1.18c. in gold. This, calculated back to the amount of water used and the ore crushed, showed a loss of $5.85 per ton of ore. Deetken also found a loss in float gold amounting to $2.26 per ton of ore.

The statement that fine gold frequently floats on water is not to be doubted.

Experiments made at the Spring Gully mines, Thornsborough, Queensland,‡ where adjoining 5-stamp batteries were run on similar ore, yielded about $30 a ton in the mortars and on the plates. The tailings from both batteries were settled, but the water was allowed to run over the settling tank in one case, while in the other it was forced to filter through the ore and to escape at the bottom. The tailings from the first tank assayed $7 a ton, while those from the second assayed $15, showing a loss in the first case of $8 a ton in suspended gold. Where the water used in former days in pan amalgamation at the Mount Morgan mine, Queensland, was returned to the boilers after a prolonged settling, the scales found on the tubes yielded 11 oz. per ton. Almarin B. Paul mentions a case where the residues from a mill water-tank, to which the water was pumped

* *Mining and Scientific Press*, Aug. 12, 1892, *et seq.*
† *Trans. A. I. M. E.*, Vol. XII.
‡ F. O'Driscoll, "Notes on the Treatment of Gold Ores."

after giving the tailings an opportunity to settle in a pit, yielded at the rate of $89 per ton in gold and silver.

The observation of this tendency of fine gold to be carried away by the strong currents of water used in hydraulic mining has led to the extensive introduction of undercurrents of less grade and far greater width than the sluices. An eminent authority on the subject* says: "Like the last concentrator the last undercurrent will always catch some metal."

Blankets and canvas over which the light suspended tailings of hydraulic mining operations have been allowed to pass have paid the owners at places in both California and Australia. So, too, quartz-mill tailings have been made to yield a profit when passed over blankets.

Remedies.—The gold in an ore may be so fine that the free-milling process is utterly unsuited to it. In this country, as well as in others, pan amalgamation is then usually tried only to be equally unsuccessful. In one case, to the writer's knowledge, pan amalgamation actually gave a smaller return than that obtained from plates.

As a general thing, if the ore is oxidized and yet the gold will not amalgamate, the chlorination process, preferably the modern barrel process, or the cyanide process, must be used. In some cases, however, where the gold is extremely fine, good results can be obtained by careful milling. To save fine gold, the discharge of the mortar should be high, the drop slow and high, and the screens fine. Crushing capacity should be sacrificed to completeness of extraction. The amount of water fed to the batteries should be carefully regulated so that a good discharge is obtained without thinning the pulp too much. On the outside a large plate area of broad plates should be provided. Preferably these should be of electroplate and with the least practicable grade.

Supplementing the plates should be a shaking amalgamating table, and if the ore does not contain a sufficient quantity of sulphides to make concentration on vanners advisable, the experiment at least of using blanket sluices fitted with the best quality of blankets should be made. Ample opportunity to allow the fine gold and fine amalgam to adhere to the plates and blankets or remain in the mortars is the secret of success and all the details should be directed to those ends.†

The Mechanical Association of the Gold with Other Minerals: (a) Gangue Matter.—The effect of gangue matter on amalgamation has not been given the attention it has merited. The experiments of Malaguti and Durocher have shown, it is true, that certain gangues are inert; others, such as clayey or talcose matters, exercise a prejudicial effect, while others, such as alum, are beneficial to amalgamation; but they have proved little beyond this, and scarcely anything of practical value to the working metallurgist. Gold in clayey or slimy pulp is difficult to amalgamate, either over plates or in pans. The pulp coats the quicksilver or plates, not giving them an opportunity to catch the

* A. J. Bowie, "Hydraulic Mining," p. 265.

† The cause of this flotation of gold is ascribed variously to the adherence to the gold of air bubbles which overcome its specific gravity, and to the grains not overcoming the cohesion of the water molecules, owing to their shape, which is said to be laminated. The first theory is probably correct, as microscopic examination of ores shows few laminated grains, nor does the pulp from the mortar show more.

gold, or it envelops the gold particles. The action of talcose pulp is the same, but perhaps in a more marked degree.

Almost invariably where the gangue is hydrated oxide of iron (limonite) considerable difficulty is experienced in amalgamation. This is partially because such ores are the products of the decomposition of pyrites, and the gold is extremely fine, but it is also due to the character of the pulp such a gangue forms. This pulp has a fairly high specific gravity, considerably above that of quartz, and if finely crushed is excessively slimy. It acts precisely like a talcose or clayey ore in preventing contact between the gold and the mercury. Such an ore is that of the Southern Cross mine, Montana. The normal ore contained 48% to 50% iron (eliminating the water of hydration) and yielded in the mortars and on plates only from 30% to 45% of its value. Pan amalgamation did even worse, from certain experiments only 25% being obtained. When the ore had the appearance of highly sintered quartz, however, most of the iron having been leached out, the results were better. It is impossible to successfully work such an ore by the ordinary milling process. Another such case where, also, the gold was in an extremely fine state of division, was that of the Mount Morgan mine, Queensland. Attempts were made in every possible manner to amalgamate this ore—over plates, in pans, and in Chilean mills—but unsuccessfully, little over 25% of the gold being extracted. When the ore was roasted, however, so that it gave up its water of hydration, the results were much better, approximating 90%. Eventually the ore was worked with great success by the barrel chlorination process, after dry crushing and roasting. A somewhat similar ore is that of the Johanna and Chainman mines of White Pine County, Nevada, which obstinately refuses to yield more than a small percentage to amalgamation. The ore of the Mercur mine, Fairfield, Utah, now being worked successfully by the cyanide process, is also of a somewhat similar nature.

The effect of heavy spar or sulphate of baryta is well known. By its high specific gravity it prevents contact of the gold or amalgam with the plates, and if the amount of water is increased so as to keep the plates clear there is danger of flooding them and washing everything away. However, heavy spar is a rather uncommon gangue material of gold ores, only one instance of such an occurrence being known to the writer—that of the Refugio mine, Sahuaripa district, Sonora, Mexico, where the ore is rather successfully treated in arrastras.

Oxides of manganese cause coating of the quicksilver and a loss of gold. It is a disputed question, however, whether manganese has any adverse action on pan amalgamation.

(*b*) *Pyrites.*—In the article on "The Cyanide Process," in THE MINERAL INDUSTRY, Vol. I., the writer advanced several arguments supporting the theory that gold as found in pyrites is in the metallic state, and chiefly confined to the crystalline faces and the cleavage planes of the mineral. Recent microscopical investigations and the earlier researches of J. Latta,* as well as the belief of modern metallurgists, are highly confirmatory of this view. This being granted the gold must be, and in fact is, in an extremely fine condition. Therefore, the direct amalgamation of such an ore is open to the same objections as with any ore in

* *Trans. Royal Society of New South Wales.*

which the gold is finely disseminated, with the added difficulty that the pyrites have a tendency to flour the quicksilver. Ores containing even as high as 22% of iron pyrites have been treated successfully by amalgamation followed by concentration. From 30% to 50% is saved by the latter operation. The pyrites have a tendency, owing to their specific gravity as well as to their physical condition after crushing, to adhere in a coating to the plates, preventing the amalgamation of the free gold. As the amalgamation of ores carrying heavy percentages of pyrites is usually attempted in pans or some similar apparatus some mention will be made of them elsewhere.

Copper pyrites are open to the same objection as iron pyrites. The powdered mineral may flour the quicksilver. Besides this, any soluble sulphate of copper resulting from decomposition may be reduced to metallic copper by the iron of the mortar. This is readily amalgamated, and the cupriferous mercury has the highly undesirable property of taking up any fine particles of iron, eventually resulting in its flouring with any contained amalgam. Zincblende or galena are rarely found in considerable percentages in gold ores; either, however, may be found associated with pyrites. Such ores as those of the Ravenswood mine, New Zealand, which contain a large quantity of zincblende, it has been found impossible to treat successfully by the ordinary milling process.

Native antimony, as well as native bismuth, is sometimes contained in gold ores. If the mercury should absorb either of these metals a loss results. However, it is the sulphides of these metals that are most to be dreaded. These cause the quicksilver to flour, and the sulphide of antimony in particular exerts a chemical action on the mercury, with the formation of metallic antimony, which amalgamates, and sulphide of mercury. According to Cosmo Newberry,* sodium amalgam does not bring the particles of quicksilver floured by sulphide of antimony together again, although it has a beneficial action on that floured by sulphide of arsenic.

Gold is sometimes found which under the microscope shows a coating of silica or silicate of iron which strenuously resists amalgamation.† The silica is generally considered to be in films of amorphous hydrated silica deposited from solution. Others have claimed that oxide of iron is frequently present as a coating, preventing amalgamation. The fine gold of the beach mines of northern California has been supposed to be so coated, and various processes, even one of boiling the sand with caustic soda, have been proposed to eliminate this scale. This process, known as the Sublette process, was not successful, it is almost needless to say.

Eggleston recommends grinding in an arrastra, claiming that in specific instances this appliance has proven more successful, many times over, than modern machinery. This latter statement is certainly open to grave doubt—but that attrition may effect some change on the so-called rusted gold is shown by the fact that in the cement gravel mills of California, where the gold is supposed to be coated, rubbers‡ are almost invariably employed.

Remedies.—In order to extract the gold from ores containing large percentages of sulphides the crushing must be fine, as in Gilpin County, Colorado. But

* "Ure's Dictionary Supplement." † Eggleston, *Trans. A. I. M. E.*, Vol. IX.

‡ Usually a cast-iron box, with a false iron bottom, on which iron shoes receive a rectilinear motion from eccentrics, and through which the pulp passes.

where the sulphurets are of high assay value, so that a considerable portion of the yield comes from their concentration, fine crushing is not advisable, as the powdered mineral is difficult to separate from the tailings, and moreover causes flouring of the mercury. Generally speaking, with such ores the concentration is the main part of the process, and the crushing should be adapted to that end. Amalgamation after roasting is sometimes practiced, as will be spoken of elsewhere.

The Chemical Combination of the Gold with Other Elements: (*a*) *Alloys.*—According to the Austrian theory of amalgamation, the separation of gold from its gangue by mercury is merely a mechanical process due to the higher specific gravity of the gold, and to the property mercury has of absorbing it. As a consequence where an electrum, or natural alloy of gold and silver occurs, the specific gravity of the metallic portions of the ore is lower than when the gold is of greater fineness, and the separation is made more difficult. At Lend, Austria, where amalgamation was practiced in Tyrolean bowls, at the time of the visit of John A. Church,* the tailings had to be smelted to recover this electrum, which assayed 15.33% gold to 84.67% silver, and had a specific gravity of only 11.28, while the free, unalloyed gold was readily saved in the bowls. At the Standard Consolidated mine, Bodie, Cal., where the average ore contained 65.6% silver to 34.4% gold by weight, and where the native gold was about 675 fine, about 60% was saved in the battery and on plates, when experiments were made on low-grade ore by the free-milling process.

Whether or not the Austrian theory is correct, ores containing a natural alloy of gold and silver, with the silver in excess, cannot be treated successfully by the free-milling process; pans must be and are invariably used, if amalgamation is employed at all.

Copper is the only other metal that is found alloyed with gold in any quantity. Usually this occurrence does not offer any insuperable objections, but the copper may become oxidized and form a coating of copper oxide which resists amalgamation. In consequence the gold is lost. Stetefeldt, in his experiments on the ores of the Los mines, Vera Cruz, Mexico,† comes to the conclusion that if copper enters the amalgam there is a low extraction of gold. At the South Clunes mill, Victoria, Australia, according to T. A. Rickard,‡ the loss of mercury rose as high as 1½ oz. per ton of ore, owing to the amalgamation of metallic copper present in the ore. There was possibly some loss of gold also.

Definite chemical combinations of the gold with arsenic or antimony are not believed to exist in ores, the gold being associated in the metallic state with the minerals of those metals. Some years ago T. Eggleston described§ an experiment on the amalgamation of gold after it had been fused with antimony and arsenic. The gold amalgamated readily, as it did when precipitated from solution as a compound of arsenic and antimony (according to Eggleston). He then quoted the statement‖ that 0.0004 gram of antimony to the ton of auriferous pyrites of Grass Valley and 0.001 gram in a ton of those of El Callao, Venezuela, were sufficient to prevent amalgamation.

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* "A Metallurgical Journey in Europe."

† *Trans. A. I. M. E.*, Vol. XIV.

‡ *Engineering and Mining Journal*, Feb. 4, 1893.

§ *Trans. A. I. M. E.*, Vol. IX.

‖ *In Comptes Rendus*, March 17, 1879. This statement the writer has been unable to confirm, and, in fact, considers the authority doubtful.

Eggleston in a later paper described * an extremely rebellious artificial ore of gold prepared by fusing metallic gold with barren arsenical pyrites. To direct amalgamation with mercury this mixture, which fortunately does not exist in nature, yielded only 25%. With the aid of cyanide of potassium 43.3% was extracted.

Native alloys of gold and bismuth have been observed and named maldonite and bismuth-aurite. Such minerals are refractory to amalgamation. W. Bertrand Roberts describes† an occurrence of the tellurides of gold and bismuth at the Mount Shamrock mine, Degilbo district, Queensland, selected specimens of which ran as high as 40% bismuth and 200 oz. gold per ton and 66% bismuth and 2170 oz. per ton. The gold would not amalgamate nor was chlorination by the Newberry-Vautin process successful. At the Bigginton mine an ore running 1% bismuth and ½ oz. gold per ton is being worked successfully, it is said, for both metals. The gold is saved on plates and the bismuth concentrated in the pulp from Frue vanners by the removal, by magnetic separators, of magnetic oxide of iron.

Tellurides of gold, and of gold and silver, accompanied by free gold, are of rather common occurrence in certain districts of Colorado, California, in a portion of Meagher County, Montana, in the Thames district, New Zealand, and in Transylvania. These ores are invariably difficult to treat by free milling. Pan amalgamation is sometimes practiced, particularly where the tellurides contain both gold and silver, or they are treated by chlorination after roasting. The tellurium minerals are friable, and considerable difficulty is encountered in saving them by concentration.

Selenides of gold have been observed by J. A. Edman‡ in the ores of the Diadem mine, Plumas County, California. The metallic gold accompanying them was of a bright yellow color, but in one case 90% of it escaped amalgamation, and showed hardly a trace of mercury on its surface. It succumbed only after a long continued grinding under smooth surfaces. Edman's tests showed that the surface was coated by selenous acid. This mineral, like the tellurides, offers many difficulties to successful concentration.

It has been proven by William Skey in a series of investigations on the ores of the Thames district, New Zealand, that native gold readily absorbs sulphur from sulphureted hydrogen or sulphide of ammonium, and that such gold, although presenting a bright surface, invariably refuses to amalgamate. He believed that this absorption was of a chemical nature, and that the film found on native gold in these ores was caused by the generation of sulphureted hydrogen by the decomposition of pyrites. After annealing this film disappears and the gold amalgamates readily.

Remedies.—When ores are to be treated which contain sulph-arsenides, sulph-antimonides, compounds of bismuth, tellurides, and selenides, associated with more or less metallic gold, the problem is exceedingly difficult. The remedy lies, possibly, in careful concentration. These minerals have a tendency to flour the mercury, and it is consequently a question whether amalgamation in the mortar should be practiced. Sufficient amalgamated plate area, and careful concentration on blankets and vanners, with the shipment to smelting works of the

* *Trans. A. I. M. E.*, Vol. XII. † *Engineering and Mining Journal*, June 25, 1892. ‡ *Op. cit.*

products of concentration, would seem the most advisable treatment. Where the gold is coated with any film there seems to be only one remedy—roasting previous to amalgamation, although it is possible that much of the gold which escapes amalgamation may be saved by the concentrators.

Improper Construction of the Plant.—When the mortar is to be considered as an amalgamating appliance, as is necessary with ores that contain fine gold, to be successful it must be broader than where rapidity of discharge is alone required. The height of the screens above the dies must be carefully considered. The plates on the outside of the battery must be of sufficient area, as is explained in that portion of this article devoted to plates. Their grade should not be excessive and their width should be at least that of the mortar. Where the grade is too steep gold and amalgam are carried off with the tailings, and where they are narrow there is an excessive rush of water.

Carelessness in Manipulation: (*a*) *Too Fine Crushing.*—Melville Attwood said a number of years ago that crushing should not be too fine; the gold should be liberated from the gangue like a kernel by the cracking of a nut. Otherwise it is left in a poor condition for amalgamation and with a tendency to float. In addition, where mercury is added in the mortar it is liable to be floured. As a matter of course, the degree of fineness to which the ore must be crushed is dependent upon the ore itself, but one thing is certain, that if a 30-mesh screen will suffice no benefit can accrue from the use of a 50-mesh. Millmen have observed frequently that there is an increase of finely divided quicksilver in the pulp when new screens have been put in the battery. Moreover, fine screens increase the percentage of slimes, which are usually richer than the ore and are difficult to treat.

(*b*) *Too Coarse Crushing.*—It may seem paradoxical that losses can occur from too coarse crushing as well as from too fine, but it is a fact nevertheless. Samples of tailings from the Homestake mill, Deadwood, S. Dak., according to H. O. Hofman,* showed on being screened 94.07%, assaying $1.25 per ton, which passed through a 50-mesh screen; 2.53% assaying $2.13, which remained on a 40-mesh; and 3.40% which passed through a 40-mesh, assaying $2.76 per ton. A sample taken later assayed $2 a ton. It showed 6% which did not pass a 30-mesh screen and which assayed $5.02 per ton.

The following results, obtained by G. F. Deetken† at Grass Valley, are of interest at this point. The ore milled $47.40 and was crushed through a No. 6 slot screen. The tailings were classified as follows: 1. Slimes which remain suspended in water 3 minutes, and which contain float gold, 19%. 2. Slimes passing an 80-mesh screen, excluding No. 1, 51%. 3. Sands passing a 40-mesh screen, excluding Nos. 1 and 2, 23%. 4. Sands remaining on 40-mesh sieve, 7%.

ASSAYS OF CLASSIFIED TAILINGS.

	Sample 1.	Sample 2.	Average.
No. 1	$12.40	$11.66	$12.03
No. 2	15.70	14.90	15.30
No. 3	34.10	22.40	28.25
No. 4	22.52	40.18	31.35

The total contents per ton of ore, estimating $2.50 to have been saved in con-

* *Trans. A. I. M. E.*, Vol. XVII. † R. W. Raymond's Reports, 1875.

centrates, was therefore $68.67, of which $18.67, or 27%, was lost in the tailings. It may be remarked here that while ores of this grade are rarely treated now in California the percentage of extraction has increased; but at some of the best mills in California, notably the Plumas-Eureka, the Sierra Buttes, and, when it was running, the Plymouth Consolidated, a good revenue was made by the owners of arrastras who reground the coarser sands roughly concentrated in the sluice-boxes.

In reference to coarse crushing it must not be forgotten that it may pay a company better to crush a large quantity with a comparatively poor extraction than a small quantity treated closely.

(*c*) *Foul Battery Water.*—The prejudicial effect of grease on amalgamation is well known. It sickens and flours the mercury and forms a scum on the plates. Condensed water from the engine should not be used for the batteries, nor should the exhaust steam be turned into the supply tank to heat it. Soapy water is well-nigh as bad. Where mine water is used it may contain acid salts of iron, which experiments have proved to be detrimental to amalgamation. These cause, moreover, the dreaded stains on the plates. The use of lime in the battery is to be recommended. Heavy lubricants which cannot run down the stamp stem should be used on the guides, and the cam-shaft boxes should be provided with drip-pans.

(*d*) *Impure Mercury.*—As has been already mentioned the presence of copper in the amalgam is detrimental. Lead, bismuth and antimony are even worse—lead perhaps the worst of all. Should this metal get into the quicksilver it will cause a loss by flotation of amalgam. Any gold bar made from retort metal containing lead is extremely brittle. Lead, like the other metals, may be partially removed by skimming and straining, but its complete removal from the quicksilver is effected only by retorting, and that under a layer of charcoal.

(*e*) *Crushing Waste with the Ore.*—The unprofitable vein filling of many mines, as well as the wall rock, which at times is unavoidably broken with the ore, frequently contains much talcose or clayey matter. The ore itself may be tough quartz, but the introduction of the waste rock into the battery places it in the undesirable condition, from a metallurgical standpoint, of being a talcose ore. Waste should be separated wherever possible, and preferably in the mine, not in the mill. The wall rock frequently contains a considerable quantity of barren iron pyrites which impoverish the concentrates.

(*f*) *The Use of Excessive Quantities of Water.*—The quantity of water necessary is dependent upon the ore, clayey, talcose ores requiring more than quartzose ores to keep the screens free. Too much water makes too thin a pulp and too rapid a current. The quantity should be carefully regulated; it is better to use rather too little than too much.

MILL CONSTRUCTION.

While it is not the intention of the writer to enter into mechanical details at length in this paper, it is necessary to speak of those features which have a direct bearing on economical and metallurgical results. In a properly constructed mill the movement of the ore from the time it enters the mill, to that when it leaves it as worthless tailings, is automatic. To effect this sufficient grade must be had

and a proper location or mill site must be selected. To reduce the expense of conveyance this should be near the mine. The question of water supply is often a serious factor in determining where the mill shall be placed. It may be cheaper to pump water to a conveniently located mill than to haul the ore to where water can be obtained under a natural head. Furthermore, there should be a proper outlet for tailings even if, as in the case of the Plymouth Consolidated Company, a long ditch must be built to carry them off.

To effect automatism in the mill, the vertical height between the concentrator floor and the rock-breaker floor should be not less than 33 ft. To attain this with a minimum of expense, the mill should be constructed on a hillside slope where possible, but where the topography does not permit of this, grade must be obtained by means of a tall structure, the ore being hoisted to the top of a tall gallows-frame at the shaft and trammed directly to the grizzlies. This construction is open to the objection that capacious ore bins will require tall, strong and expensive under-structures.

The following is a synopsis of the treatment through which the ore passes: The ore trammed in cars is discharged upon grizzlies which separate it into two classes: 1. Fine, which falls directly into the ore bin. 2. Coarse, which goes to the rock-breakers or rolls, and after being crushed to the proper size, to the ore bins. 3. The ore from the ore bins passes through the self-feeders to the batteries, where it is crushed to the proper size and a portion of the gold retained in the mortars. Thence the crushed pulp passes over amalgamated plates, which retain a further quantity of gold, then to the concentrating appliances, which save the gold-bearing sulphides with a further quantity of free gold or amalgam. After this the ore is considered as tailings and is usually allowed to run to waste.

Grizzlies.—These are coarse screens, formed of rectangular wrought-iron bars placed at a greater angle than the natural one of repose of coarse crushed rock; the bars are held apart by rods and washers. Their length is usually about 12 ft. The bars are generally about 1 in. wide and 3 to 4 in. deep, held 1½ in. apart. The number of grizzlies and their position depend upon the capacity of the mill and the number of rock-breakers. Sometimes the coarse ore from them falls on the rock-breaker floor and from there is shoveled into the breakers, which are set flush with the floor. A preferable construction is to have the grizzlies act as a floor to a coarse ore bin, from which, by means of a chute, the ore is drawn off directly into the breaker. After crushing it rejoins the ore which has passed through the grizzlies to the main ore bin.

Rock-Breakers.—There are many varieties of these, but those which have won the greatest favor among millmen are the Gates and the Blake, and in mills of small capacity the much lighter Dodge breaker. In mills of great capacity the Gates crusher has been found to be exceedingly economical. According to H. O. Hofman,* one No. 6 Gates breaker at the Caledonia mill replaced three No. 5 Blake crushers, requiring at the same time no more power. In addition only one laborer was required in place of five. Two hundred tons were crushed in 10 hours, whereas with the Blakes this was only accomplished in 20 hours. The

* *Trans. A. I. M. E.*, Vol. XVII.

saving was estimated at $27 per day. This breaker weighed 15 tons. To obviate the breaking of the large lumps of ore by sledges prior to feeding to the breakers, H. O. Hofman recommends that an 18 by 48 in. mouth Gates crusher, discharging into two 12 by 18 in. crushers, be used. This is a good arrangement, particularly if the lower breakers be so set as to crush finer than the usual size; thus the capacity of the mill will be increased, but more fall will be required.

The repairs on rock-breakers are not excessive. Those on eight Blake breakers 7 by 15 in. at Bonne Terre, Mo., crushing lead ore in limestone during 12 months, in which period 224,203 tons of ore were crushed, are given by H. S. Munroe* as follows: Twelve levers at $25; 9 jaw-plates at $15; 12 jaw-plates at $12; toggles, cheek-plates and sundries, $250—total, $829. This expenditure, which did not include labor, repairs or babbiting the bearings, amounted to 0.037c. per ton. The principal portion of the wear is on the shoe and die jaw-plates. The dies usually last twice as long as the shoes. Steel shoes and dies have the longest life.

Ore Bins.—While these receptacles would not seem to play any important part in successful milling, yet their improper construction may entail extra labor and inconvenience. If the bottoms have too slight an angle, or if the boards forming them are placed transversely instead of with their length in the direction of the slope, the ore will not move forward automatically. The slope is generally 45°, and the bottoms of two layers of plank, the upper one of 1-in. boards running in the direction of the slope and the lower one of 2-in. or 3-in. planks at right angles to the upper. Owing to this arrangement the upper planks when worn can be replaced. Where the ore drops on the floors heavy iron plates are frequently placed, increasing the life of the wood bottoms. The lowest portion of the bins is at the level of the cam-shaft floor. At each 5-stamp battery there is a chute which discharges the ore into the hoppers of the self-feeders, the discharge door being raised and lowered by a rack and pinion.

Self-Feeders.—While it is quite possible, as is claimed by old-time millmen, and by modern ones in Australasia, that the regular feeding, upon which is dependent the crushing capacity of the stamps, can be effected by intelligent hand-feeding, yet the machine feeder is now almost universally used.

It is certain that the self-feeder will deliver a uniform quantity of ore to the battery, and if for no other reason than economy it is to be preferred. In mills where the crushing capacity of the stamps is small a man can attend to possibly 25 stamps; in other cases 15 is the maximum. Thus in a 75-stamp mill the cost of hand-feeding will vary from $30 to $18 per day, with labor at $3 per shift. This would be exceedingly good interest on the cost (approximately $3750) of 15 automatic feeders. Besides, with self-feeders the life of the wearing parts of the battery is lengthened and, as has been proven, the capacity of the mill is materially increased. Feeders depend upon two general principles: that of a revolving carrier, which may be a plane or a barrel, and that of the percussion table. The barrel or roller feeder has a tendency to deliver the ore to the two center stamps. The revolving table distributes it uniformly. However, either is better in this respect than the percussion table feeder. The latter has also the objection of delivering the ore with less regularity. The roller and

* *Trans. A. I. M. E.*, Vol. XVII.

table feeders, moreover, deliver wet or clayey ores extremely well. Their wearing parts last longer, but their construction is somewhat more complicated than that of the percussion table feeder.

To secure uniform working of the feeders the ore must be delivered to them of a uniform size. They are driven by the tappet of the center stamp, in the case of the Hendy Challenge table feeder, or that of the second or fourth stamps in the case of the Tullock percussion feeder, striking a bumper rod connected with the feeder. They feed either directly into the mouth of the mortar or into a small apron which delivers the ore to the mouth. The former arrangement is the more common. The Suspended Challenge feeder allows easy access to the back of the mortar, as the ordinary carriages are done away with.

The Mortars.—The modern American mortar has been evolved from long experience. It is commonly constructed with either of two ends in view: The amalgamation of a large portion of the gold inside of it or the crushing of a large amount of ore. In the former case it is wide and frequently deep; in the latter it is narrow and ordinarily quite shallow. The crudest form of mortar is that used in Gilpin County, Colorado, and in a number of mountainous regions to which the freighting of a heavy cast-iron mortar would be well-nigh impossible. The Gilpin County mortar is a shallow, though thick, cast-iron trough which does not extend above the die. Around and above this is a wooden housing, faced with heavy iron plates at the feed side. It is made comparatively broad, with the idea of retaining the pulp as long as possible.

The mortar most commonly used is a solid iron casting varying from 7½ in. thick on the bottom, 3 in. on the lower sides to 1½ in. at the upper portion. They are from 48 to 56 in. long and weigh from 4800 to even 6400 lbs. The feed opening, 3 to 4 in. wide, is at the back, and should extend the full length of the mortar. This is from 7 in. to 1 ft. deep. At the bottom mortars vary from 10 to 16 in. wide, and at the top from 12 to 20 in. The discharge opening is in front, and provision is made for tightly locking a screen frame against it, at a slight outward angle from the perpendicular, by horizontal and perpendicular keys. The top is of 2-in. plank in two pieces resting on lugs. To allow for the passage of the stems there are semicircular openings in each piece. In addition there are holes for the water pipes. As is mentioned elsewhere, the plates are placed below the screen, either bolted to the mortar or on a chuck block, and under the feed lip, which protects them from falling ore in case a back plate is used. Interior linings of cast iron are frequently made for the mortars, particularly for the sides, where the wear seems to be greater. A set of linings will wear from 6 to 9 months.

Double discharge mortars are of rare occurrence in the United States, at least in gold mills, they being confined to the coarse crushing auriferous cement mills.

At the South Clunes mine, Victoria, Australia, double discharge mortars are used, however,* and appear to be entirely suitable to the system of amalgamation practiced there. The objections urged against these mortars are that the discharge is so rapid that no time is given for amalgamation; that the copper

*See T. A. Rickard, *Engineering and Mining Journal*, Jan. 28, 1893.

plates cannot be arranged properly in them, and that too much battery water is used for the concentration which usually follows. At Clunes no quicksilver nor plates are used in the mortar, yet by gravity alone 44.8% of the gold obtained, including that from concentrates, is saved in the mortar.

Plates on chuck blocks would probably answer as in the single discharge mortars; the large amount of water required is perhaps the most valid objection. Mortars of peculiar construction, such as that at the Harrietville mill, Victoria, Australia, described by T. A. Rickard,* have not met with introduction in the United States. The one just mentioned has both a front and end discharge. The end sections are curved and the screens there are coarser than in front. This form of mortar allows the use of plates wider than the mortar itself. At this mill they are 6 ft. wide. The coarse screens at the ends are said to cause a regular discharge.

The life of a mortar depends to a great extent upon the character of the casting and to a greater degree still upon the rigidity of the foundation. Some castings have a tendency to crack at the junction of the back and sides so that they are now often cast with a fillet there. Where possible the pit for the block should be dug to clean bed-rock, and the space up to the mudsills filled around the blocks with concrete. The blocks should be of two single pieces of timber 30 in. thick and wide enough to fill the space between the battery posts. Where these large timbers cannot be procured it is frequently the custom to use planks spiked together and bound by binders. At the Homestake mill† the planks are placed with their width parallel to the long side of the mortar. The bolts holding the mortar down are threaded at their upper end only; the lower ends have a loop. Through these loops and through the mortar blocks 2-in. iron rods pass horizontally. This secures the mortar well, and in addition the mortar block can be readily changed. Immediately underneath the mortar and on top of the block a piece of rubber $\frac{1}{4}$ in. thick is sometimes placed. The life of a mortar block is dependent upon the quality of the timber as well as the degree of moisture to which it is exposed. Sugar pine, yellow pine or Oregon pine are considered the best woods.

Screens.—Screens not only differ in size but in the material from which they are made, and in the character of the openings. They are most commonly made of Russia iron, punched or slotted. Aluminum bronze has been used, it is said, with good effect. Copper has also been tried where amalgamation in the mortar is not practiced. According to T. A. Rickard‡ copper screens used at the South Clunes and Port Phillip mills, Victoria, Australia, lasted as long as from 12 to 18 months when manufactured of imported English copper. Those made from the domestic article lasted a month as against a week for Russia iron.§

Tin screens, with the tin burned off, have been used with some apparent advantage at a number of Californian mills. They do not last so long as Russia iron, but owing to their wear and to their thinness they discharge rapidly and their first cost is low.

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* *Engineering and Mining Journal*, June 10, 1893.

† H. O. Hofman, *Trans. A. I. M. E.*, Vol. XVII.

‡ *Engineering and Mining Journal*, Feb. 4, 1893.

§ It would seem that it might be well to try copper screens where silver ores are wet crushed.

The first cost of brass wire screens is less than slotted or needle-punched Russia iron, but their wear is greater, so that the advantage lies with the latter to a certain degree. The former have a greater discharge area and the pulp is of more uniform size. Contrary to the opinion of some millmen, brass wire screens will not amalgamate. Their worst tendency is to break and wear at the bottom edge of the screen frame. Russia-iron screens are made with horizontal, vertical or angled slots, $\frac{1}{4}$, $\frac{3}{8}$ or $\frac{1}{2}$ in. long, and may be punched so that there is a rough, burred edge on the side, which is placed on the inside of the mortar. The numbers of the slot and punched screens are derived from those of the needles which can pass the slot or through the perforation. The mesh screens are designated by the number of meshes to the square inch. The following table is taken from an article by John Hays Hammond :*

No. of Needle.	Corresponding Mesh.	Width of Slot, Inches.	Thickness of Iron, Russian Gauge, No.	Thickness of Iron, American Gauge, No.	Weight per Square Foot, lbs.
5	20	.029	14	23¼	1.15
6	25	.027	13	24	1.03
7	30	.024	12	24½	0.987
8	35	.022	11	25	0.918
9	40	.020	10	26	0.827
10	50	.018	9	27	0.735
11	55	.016	8	28	0.666
12	60	.015	8	28	0.656

The size of screen to be employed is dependent upon the ore and the condition of its gold. Ore with extremely fine gold must be crushed fine, whereas with coarse gold it would be folly to do so. Thus in Amador County, where the gold is coarse, No. 6 or 7 slot screens are most frequently employed. So, too, in Nevada County a 30-mesh screen is of frequent occurrence, while in Calaveras County, where the gold is finer, 50-mesh and 9 or 10 angle slot are not unusual.

In Gilpin County, Colorado, where the gold is also fine, slot screens corresponding to 40, 50 and 60-mesh are employed. The size of the screen not infrequently gives an erroneous idea of the size of the pulp. Thus at the Bobtail mill, Gilpin County, according to A. N. Rogers,† where an 80-mesh screen was employed, there remained on a 40-mesh screen 1.17%; on a 60-mesh, 17.55%; on an 80-mesh, 13.08%; on a 100-mesh, 10.33%; and 57.87%, much of which must have been impalpable powder, passed this last screen. According to data found elsewhere in this article, ore crushed through a 6-slot screen at Grass Valley, California, had 19% of slimes which remained in suspension in water 3 minutes, and 51% which passed through an 80-mesh screen. Of ore crushed through a 25-mesh screen, 12% remained on a 40-mesh, 31% on a 50-mesh, 10% on a 70-mesh and 47% passed a 100-mesh. Where ore was crushed wet through a 20-mesh screen the following results were obtained:

	Per cent.		Per cent.
Pulp resting on a 20-mesh screen	0.0	Pulp resting on a 100-mesh screen	7.1
" " 30 " "	43.0	" " 120 " "	4.8
" " 50 " "	29.5	" " 150 " "	4.2
" " 57 " "	5.3	" passing a 150 " "	7.8

Too fine screens may cause a loss in the after concentration. The size that should be employed should be carefully determined by experiment and the assay of tailings.

* "Gold Milling in California," *Report of State Mineralogist*, 1888. † *Trans. A. I. M. E.*, Vol. XI.

The wear of screens is dependent upon the physical character, and also, to a lesser degree, upon the chemical character of the ore. Hard quartz will be frequently thrown violently against the screen, often tearing holes in it. Narrow mortars tend to produce this result also, and careless feeding may play a part. If the screens are too wide they may break also by the pressure of water when they have become stopped up by chips. Russia iron screens last from one week to ten weeks. Their average life is about one month. The effect of impure water or the acid sulphates of certain ores may have on them is well shown by the results in Gilpin County, Colorado, according to T. A. Rickard.*

The Hidden Treasure, Prize, Gregory-Bobtail, New York, and Randolph mills are all on the same stream. The Hidden Treasure receives clean water but returns it into the creek, impregnated with a certain amount of acid sulphates. The Prize does likewise. At the Gregory-Bobtail the strongly acid mine waters are turned in, and before the waters reach the New York and Randolph mills they are further contaminated by washing past banks charged with more or less decomposed pyrites. The life of the screens are as follows: Hidden Treasure, 81 days; Prize, 75 days; Gregory-Bobtail, 60 days; New York, 25 days; Randolph, 16 days.

The average life of brass wire screens is only two weeks.

The screen frames are of wood divided by ribs into panels. The width of screen exposed depends upon the width of the mortar, and the height upon the local practice. Screens are made sometimes 13 in. deep, but this is usually where they are of brass wire and are to be reversed. A more common depth for slot screens is 9 in., 7 in. of which is in the clear. When chuck blocks are used the screen frames usually rest upon them, and a more or less uniform height of the edge of the screen above the dies is maintained by changing the chuck blocks.

Russia iron screens are usually fastened to the frames with small shingle nails or heavy tacks. For brass wire copper tacks or, occasionally, copper screws are used.

When the screens are fastened to the frames strips of blanketing or of rubber cloth are nailed over the lap on the frame, with the idea of making a close joint with the mortar.

Shoes and Dies.—Shoes and dies are manufactured of wrought iron, cast iron, of various grades of cast steel, forged steel, chrome steel, or manganese steel. The choice of the metal is dependent not only upon the wear but upon local conditions. Chrome or other steel shoes and dies may outlast those of cast iron, but the iron scrap can be sold to local foundries. Thus it may be more profitable to use the latter. Certain qualities of steel shoes have, at times, the undesirable property of cupping—even deep holes may be worn in them. The writer has seen steel shoes in which holes had been worn through the shank up to the boss. At the Utica mill, Angel's Camp, Calaveras County, California, the use of cast-iron dies with steel shoes has proved very satisfactory. The wear of both is said to be more even than when they were of similar metals. The wear of shoes and dies depends upon the preparation of the ore, uniform feeding, and the metals of which they are composed. It has been shown by T. A. Rickard,†

* *Engineering and Mining Journal*, Sept. 3, 1892. † *Ibid.*, Sept. 23, 1893.

in an elaborate analysis of the wear of shoes and dies, that in Australia, where rock-breakers were not used, the wear of the shoes and dies was invariably high. And from some of his data the inference is to be drawn that if grizzlies are not employed the consumption of shoes and dies is increased also. It certainly is reasonable, that if the ore is coarsely spalled with sledge-hammers, not only will the comparatively large pieces of hard quartz tend to occasion uneven and excessive wear of iron, but with such ore neither hand nor automatic feeding can be regular. If the feeding is uneven iron may be pounding on iron one minute while in the next the dies are covered deep. Generally the aim of a feeder is to keep the ore low on the dies. This ensures an increased crushing capacity, but at the same time it has been observed that when the feeding is low the wear is greater.

Not only is the quality of the metal employed in their manufacture a serious factor, but the relative degree of hardness or toughness of the shoes and dies is to be taken into consideration. As Rickard puts it, "The analogy of the hammer and the anvil shows that the metal of the anvil should be, and is, softer and tougher than that of the hammer." This is the reason of the good results referred to at Angel's Camp.

The actual cost for shoes and dies per ton of ore crushed is as variable as the consumption of metal per ton. It may be said to be between 5c. and 27c. per ton, depending upon the actual wear and the cost of the materials at the mine. The average in this country may be estimated at 8c.

Cast-iron shoes last from 40 days to 3 months. The dies usually last longer. Chrome steel shoes may last 9 to 10 months, but will average about 6 months. Compressed steel shoes, forged by hydraulic pressure, have given good results, and shoes of iron to which a little chrome steel scrap has been added in the cupola have been found to wear much better than those of iron alone. Manganese steel has been tested recently and is said to give excellent results.

The weight of the shoes varies with that of the stamp. Iron shoes weigh from 120 to 140 lbs.; those of chrome steel from 140 to 155 lbs. for stamps of from 850 to 950 lbs. weight. Dies to match these shoes weigh from 110 to 129 lbs. Iron dies weigh from 95 to 115 lbs.

The shoes are nearly always circular in section, from 9 to 10 in. in diameter, and from $7\frac{1}{2}$ to 8 in. deep. The neck tapered to meet the boss is about $4\frac{3}{4}$ in. in diameter at the base and $4\frac{1}{2}$ to 5 in. long. The dies are usually circular in section, but are sometimes octagonal. Their section on the bottom is usually square with the corners beveled off to allow their ready removal from the mortar. They should be as wide as the mortar bottom, and their united length should equal its length.

The bosses or stamp heads were nearly always made of iron, but lately steel has come into general use. They were provided with sockets for the shoe and stem, and with drift-ways from the removal of these. If the bosses are of cast iron, wrought iron rings are shrunk on them at the top and bottom. The stem is of wrought iron or of mild steel. They last several years and are reversible. The most frequent cause of accident is allowing the ore to run too low in the mortar. This is apt to break off the stem where it enters the boss. A new form of cam, locally called the "bally" cam, has been introduced in South Africa. It is constructed

so that the arms strike the tappet of the stem to the right and left of it alternately, thus giving the stems alternately a rotary motion to the right and to the left. The claim that it causes more even wear of the shoes and dies, as well as of the tappets, would seem to have a logical basis. The cams and tappets are now usually made of steel, chrome steel being the favorite metal.

The Weight of Stamps.—The general tendency in the United States in late years has been to increase the weight of the stamps. The limit, however, seems to be about 850 lbs. The following table contains the average record of 102 Californian mills, 29 of which have stamps weighing 850 lbs., and many of which exhibit the best practice of the State. The table shows beyond question that with increased weight the capacity is increased, but owing to the variable number of observations and the unknown incalculable, but important, factors which enter into the crushing efficiently it is impossible without interpolation to construct a mathematical series showing the ratio between weight and crushing capacity.

THE WEIGHT AND CRUSHING CAPACITY OF CALIFORNIAN STAMPS.

Weight of Stamp.	No. of Mills.	Drop in Inches.	No. of Drops per Minute.	Tons Crushed per Stamp in 24 Hours.	Horse-power Developed.	Tons Crushed per Horse-power in 24 Hours.
400	2	5	100	0.87	0.505	1.772
450	1	6	80	1.25	0.545	2.110
550	2	4.1	70	1.12	0.398	2.844
600	4	5.8	81	1.30	0.711	1.828
650	8	6.3	80	1.27	0.824	1.541
700	5	7.2	88	1.80	1.120	1.606
750	25	6.6	86	2.06	1.075	1.916
800	8	6.5	87	1.73	1.142	1.514
850	29	6.3	88	2.47	1.187	2.087
900	8	6.9	85	2.24	1.333	1.680
950	6	6.7	87	2.58	1.368	1.900
1000	4	8	93	2.50	1.878	1.331

The light stamps, though their tonnage is small, have an extremely good record when the proportion between the tons crushed and horse-power developed for 24 hours is considered. The worst record so calculated is that of the 1000-lb. stamp, which crushes only 1.331 tons per horse-power for 24 hours. The 750-lb. stamp, the crushing record of which was taken in 25 mills, shows 1.916 tons crushed per horse-power for 24 hours, while the 850-lb. stamp, with observations in 29 mills, shows a slightly increased crushing efficiency, with 2.087 tons. Calculating from the crushing efficiency of the 750-lb. stamp, and the horse-powers developed by both the 750 and 850-lb. stamps, we should expect 2.115 tons crushed in 24 hours, a difference between the actual and calculated result of only 56 lbs. of ore in 24 hours. This would seem to indicate that where a large and nearly equal number of observations can be made of mills using different weight stamps, the figures representing efficiency are fairly correct. The only way, however, to have absolutely correct data is to crush identical ore, in similar mortars, with screens of the same mesh, with stamps of differing weight. This probably will never be done, so the conclusion may at once be come to that the most efficient stamp lies between 750 and 850 lbs., with a drop of from 6 to 7 in., from 85 to 95 times a minute.

The Drop of Stamps.—The height of drop differs with the weight of the stamp, the speed with which it is run, and the object to be attained. Califor-

nian practice, as well as that at the Homestake mills, is a fairly low drop and a high speed of a heavy stamp. The drop varies from 4 to 9 in. in these localities, where the gold is comparatively coarse, and no particular attempt is made at fine crushing and the retention of gold in the mortar. In California frequently the drop is so low that the bottom of the shoe does not rise above the lower edge of the screen, and in consequence the stamp is not removed from the water. This is done to assist the collection of amalgam on the inside plates, as well as to prevent a too violent splash. In Gilpin County, Colorado, the drop, with a stamp weighing from 500 to 650 lbs., is from 16 to 18 in., and in consequence of the high lift the speed is low—from 26 to 32 drops per minute. Here the interval between the drops allows the subsidence of amalgam in the mortar. It is safe to say that with a comparatively low drop, rarely exceeding 8 in., and with a speed of from 85 to 95 drops per minute, more ore will be crushed than with a higher drop, lighter stamp and slower speed, but, at the same time, the percentage amalgamated in the mortar, particularly if the gold is fine, will be lower.

The order of drop varies with the ideas of millmen. The object of a definite order of drop is not only to produce a good splash, which will facilitate the discharge and amalgamation on both the inside and outside plates, but to equalize the strain on the cam-shaft and the motor, and to keep the ore constantly on the dies. Favorite orders of drop are 1, 4, 5, 2, 3; 1, 3, 5, 2, 4; 1, 4, 2, 5, 3. The idea is that adjacent stamps should not drop consecutively. Furthermore, where, as is usual, 10 stamps are driven by one cam-shaft, similar stamps in the adjacent batteries are not to be lifted simultaneously. Thus, if the order 1, 4, 5, 2, 3 is adopted the order of the 10 stamps will be 1, 8, 4, 10, 2, 7, 5, 9, 3, 6.

Guides.—The guides which hold the stems in position are usually of hard wood, bolted to the transverse timbers, which tie the battery posts together. These guides, both the upper and lower, are bolted with from 8 to 12 bolts to the timber behind. To remove a stem, therefore, from 16 to 24 bolts must be taken off and then replaced when the new stem is put in. For this reason sectional or individual guides are coming into favor. These allow the ready removal of the stem, and the cost of renewal of the wearing parts is less, as the wood blocks are small.

Above the line of batteries is placed a traveling crane to lift the stems when the dies are to be changed or the stem to be taken out. In some places the stamp is lifted, when the former operation is to take place, with an iron bar as a lever, through the mortar front, and there kept in position by a wooden block placed on the finger which supports the stamp when "hung up."

Aprons and Sluices.—Some mortars have a cast-iron apron placed in front, bolted to the mortar into which the apron plates are fastened by wooden blocks. Other mortars discharge directly over a lip on to the apron. In that case the apron frame is of wood, and the plates are usually fastened to it with steel screws. The frame is made so that the pitch of the apron is readily adjustable. The grade of apron plates varies from $\frac{3}{4}$ in. to the foot to 2 in. to the foot. Attention is called elsewhere to the importance of a careful regulation of this. The smallest grade which will keep the plates clear of heavy sands and sulphurets is the best for amalgamation. Below the apron and sluice-plates are the shaking

amalgamating tables, which are given a longitudinal thrust, and should have less grade than the sluices.

Mercury Traps.—These, which are usually simple cast-iron boxes, tapering toward the bottom, into which the pulp is delivered by an iron pipe near the bottom, have been found to be excellent savers of mercury and amalgam at various mills. The outlet is near the top, and in order to prevent a strong upward current which might carry away any suspended amalgam, a piece of 2-in. plank is bolted on the discharge side. This breaks the current. At the Homestake 80-stamp mill, according to Hofman, traps placed at the end of the apron recover 80 ozs. of amalgam and 144 ozs. of quicksilver, while additional ones at the end of the outside sluice-plates save 40 ozs. of quicksilver and 10 to 12 ozs. of amalgam every month. These traps are slightly different from the one described, being divided by means of iron plates into partitions under and over which the pulp flows.

Blanket Sluices and Concentration.—Saving gold or amalgam by means of blankets, cloth with a pronounced nap, or hides with the woolly side up, is one of the original methods. It is practiced to-day to a large extent in Australasia and in Brazil, while there are comparatively few mills using them in the United States. Blanket sluices are generally 17 to 18 in. wide, where the mill blanket made 21 in. wide, and with the nap on one side, is used. They are from 4 ft. to 18 ft. long, according to the dependence placed upon them, and generally the pulp from one battery is passed over three such sluices. The grade of the sluices varies from $\frac{3}{4}$ in. to $1\frac{1}{2}$ in. to the foot. The washing of the blankets is periodical, depending upon the richness of the ore; on rich ore the upper blankets, where plate amalgamation is not practiced, are washed every half hour, and the lower ones once in two hours. The washing is done by picking the blankets up in several folds, then releasing the lower end in a box filled with water and agitating the blanket rather violently. The blankets are commonly $5\frac{1}{2}$ ft. long, and when placed in a sluice the upper laps over the lower.

Blanket washings are usually treated in pans or amalgamating barrels. They consist of sulphurets, a certain amount of gangue, amalgam and unamalgamated gold. There is little data to be had on the efficiency of blankets where they are used in this country, but their use has many supporters in Australasia, some even going so far as to believe in their substitution for amalgamation in the battery and on plates. At the Premier mill, Macetown, New Zealand, according to Rickard,* where amalgamation is practiced in the battery, after which there are blankets and then copper plates, the percentage of saving is as follows : Mortars 60%, blankets 33%, and plates 7%. This is rather an unusual order, but shows the efficiency of the strakes. However, when the copper plates were introduced it was found that about 5% more amalgam was saved. At the Phœnix mill, in the Otago district, New Zealand, where no amalgamation was practiced, gold being collected in the mortar-box by the aid of gravity alone, and on the outside by green baize, the percentage of what was saved was 61% in the mortar and 39% from the strakes. According to the same writer, at South Clunes, Victoria, 17.1% of the yield came from the blankets, which supplemented the collection of gold by

* *Engineering and Mining Journal*, March 18, 1893.

gravity in the mortar and by mercury wells on the outside. At Port Phillip, where the ore has gradually increased in rebelliousness, the saving by blankets has increased, while that of the mortar and wells has decreased.

Speaking generally it would seem probable that blankets are efficient savers of gold where the ore is not sulphureted and the gold rather coarse. Blankets and gunny sacks in one case, to the writer's knowledge, saved fine gold which could not be saved by plates.

Water.—Water is used in a gold mill, in the batteries, on the outside plates when they are being cleaned, and on the concentrators. A further supply is needed for the retorts, clean-up tank and barrel, or pan if one is used, and the boilers if it is a steam mill, but the main quantity is that needed for the batteries. This is estimated at from 1 to 1½ miner's inches* per 24 hours for each battery. While the amount used in the battery, and on the concentrators, varies with the ore, clayey ores and those heavily sulphureted requiring the most water, the total amount required for the mill will never exceed 2 miner's inches to the 5-stamp battery. Some millmen believe in heating the battery water, but it would seem doubtful if this can produce any result other than to create a fluid amalgam. The plates in particular are softer when warm water is used, but this is a doubtful advantage. If the water be heated at all it should not be done by the direct application of the exhaust steam, as is explained elsewhere.

THE AMALGAMATED PLATES.

Plates used in the amalgamation of gold are commonly of copper, often with a coating of silver deposited electrolytically. For amalgamation inside the mortar plain coppers are almost invariably employed, although some ill-advised mill builders have used silver-plated coppers in the battery. The objection to this is that they do not seem to catch the coarser particles of gold as readily as the mercurialized plain copper, and moreover, being exposed to abrasion by the coarser particles of ore an extra expense is involved, as their first cost is greater. When the inside plate is on a chuck-block this objection is not so marked.

In some Australasian districts, notably The Thames, New Zealand, plates manufactured of an alloy known as Muntz metal† are said to give satisfaction. However, when tried in this country their tendency to become brittle when saturated with amalgam, and to break when being cleaned, has led to their abandonment.

In the United States, particularly in California, the silver-plated coppers have met with deserved popularity, so that few modern mills are unsupplied with at least a certain area of them. As evidence of their efficiency Rickard cites‡ an instance at the Harrietville mill, The Ovens, Victoria, where two adjoining batteries were fitted with copper and silver-plated copper plates in the following order: No. 5 battery, silver-plated copper, plain copper and plain copper; No. 4 battery, silver-plated copper, silver-plated copper and plain copper. After a year's run on similar ore it was found that the final copper of

* The miner's inch is 2260.8 cu. ft. in 24 hours under 7 in. head, discharging through a 2-in. square opening in a 3 in. plank, the outer inch of the orifice being chamfered. This is equal to about 16,800 gals.

† An alloy of 40% zinc and 60% copper, used commonly for sheathing the bottoms of vessels.

‡ *Engineering and Mining Journal*, June, 10, 1893.

No. 4 battery had caught no considerable amount of amalgam, while the final plate of No. 5 battery had become well amalgamated. The inference is that the second silver-plated plate of No. 4 battery had caught the amalgam, and that the second plain copper of No. 5 battery had allowed some to escape. At the 60-stamp mill of the Sierra Buttes Mining Company, Sierra County, California, silver plates were discarded on account of their wear, the silver being abraded rapidly, while at a 20-stamp mill of the same company they were in successful use. This complaint of the wearing out of the silver coating is one that is brought up rather frequently. In this instance, at least, this result is open to two explanations, the one mechanical, the other chemical. In the first place the sluices—there are no aprons employed at the Sierra Buttes—are only 15 in. wide, and into this narrow space the pulp from 5 stamps, with, approximately, 1½ miner's inches of water, is turned in a flood. The necessarily swift current and the sharp particles of quartz may accomplish the result complained of. Secondly, the 20-stamp mill treats old dumps and thoroughly decomposed surface rock, while the ore milled at the 60-stamp mill comes from deep levels and is nearly undecomposed. It may be possible that some of the constituents of this latter ore may exert a chemical action on the silver. It is not clear that this can be the case, so that the writer is inclined to the mechanical theory.

Generally speaking, the silver-plated coppers are more efficacious than plain coppers when the gold is fine, but this statement does not imply that the coppers are better savers of coarse gold except when placed in the mortars. Another argument, and a potent one in their favor, is that the silver-plated plates are more easily kept in good condition, and are not so apt to get the green discoloration common to plain copper. Their cost is not a serious objection and is considerably lessened if the mill is of sufficient size to own its own plant for the electro-deposition of the silver. Plates manufactured from the best Lake copper, with a plating of ½ oz. silver to the square foot—the common quantity—cost at the manufacturer's about $2.50 per sq. ft. Manufactured by the company itself, the cost would be little more than that of the copper and silver employed. The coppers are sometimes plated as heavily as 3 oz. silver to the sq. ft., but it is not generally believed that any advantage acrues from this excessive coating, which is open to the objection of high cost.

Preparation of Plates.—Lake copper is usually delivered to the mills in such condition as to require no annealing before it will readily absorb quicksilver. Should the plate, however, have been so treated in the rolling process that its pores are closed, it is necessary to expose it to a certain degree of heat before it is prepared for amalgamation. The side which is not intended to form the amalgamating surface may be placed over a fire—a blacksmith's forge will answer—and heated sufficiently to ignite shavings or sawdust placed on the upper surface. Heating must not be carried to such a point as to oxidize the copper. It will now be in a condition for after treatment. This varies according to the practice of the millman. The first essential, however, is to thoroughly scour the surface. The process recommended by N. S. Keith is as follows: The plate is scoured with a thick mixture of ashes, sand and water by the aid of a small block of wood. It is then washed thoroughly with water and cyanide of

potassium solution applied with a brush. This should remove all grease and surface oxidation and the plate can be amalgamated. Enough water is added to a mixture of equal parts of sal ammoniac and sand to form a thick pulp. This is spread over the plate, and on the mixture is sprinkled enough quicksilver to thoroughly coat the surface. After this has remained on the plate for an hour or so it is washed off with water and the process repeated three or four times. This is said to leave the plate in thoroughly good condition, and where it is done carefully it is certainly better, and has proved more satisfactory, than any process in which acid is used.

The process for treating new plates in use at the Homestake mill, Deadwood, S. Dak., where no silver-plated plates are used, as described by Hofman,* was as follows: The plates, which do not require annealing, are scoured with sandpaper followed by emery cloth, or with tailings and a wooden block, or with a grindstone, until the surface is perfectly bright. The sand may be moistened with a weak solution of cyanide of potassium, and nitric acid is often employed to remove the spots. A strong solution of cyanide is then repeatedly applied with a paint brush. After two days the mercury is sprinkled on this cyanide coat and rubbed into the plate with a moist cloth and tailings.

It is not surprising that after this process, which is deficient in cleansing properties, for several weeks the plates should be discolored, particularly if any acid has been used. To remove the discoloration the peculiar remedy of introducing cyanide or ammonia into the battery water is employed. However, an additional quantity of mercury added in the mortar brings the plates to proper condition in from 2 to 4 weeks.

The only experiments on the cause and remedy for the tarnishing of amalgamated plates were made by the late C. H. Aaron.† These will bear quotation:

"Pieces of copper were coated with quicksilver and exposed to immersion in Spring Valley water.‡ The plates amalgamated with the aid of nitric acid, and mercuric chloride were tarnished in a few minutes and on being cleaned with a solution of potassium cyanide, washed in water and again exposed, were again promptly tarnished, and so on indefinitely. Plates amalgamated by means of potassium cyanide, not using nitric acid, resisted tarnishing during the first hour, after which they behaved in the same manner as those on which nitric acid was used. Tarnishing was lessened by the addition of slaked lime to the water and was prevented by a small amount of ferrous sulphate;§ also by a trace of potassium bisulphate, but not at all by caustic potash. Tarnishing was permanently prevented by placing an iron nail in contact with the amalgamated strip of sheet copper; also by contact with a piece of zinc. This makes a galvanic couple, and the oxidation is transferred to the more positive iron or zinc. Iron pyrites on the plate and in the water had no perceptible effect. One of the strips was smeared with zinc amalgam, and it remained bright for a number of hours, but after 24 hours it was slightly tarnished. Another strip treated with mercury containing a little cadmium retained its color three days."

Aaron's recommendations were as follows:

"1. Place some bars of iron on the apron; say one across the upper end and one on each side edge, also one in the middle. 2. Use zinc amalgam on the apron. 3. Dissolve a little cadmium in the quicksilver for use on the apron and in the mortar. 4. Fix a tank so as to

* *Trans. A. I. M. E.*, Vol. XVII.

† *Engineering and Mining Journal*, Aug. 10, 1889.

‡ The common hydrant water of San Francisco.

§ This seems peculiar when we consider that many observers have thought that this discoloration was due to the action of sulphates of iron and sulphuric acid, rarely absent in ores which contain pyrites.

deliver a small stream of water containing potassium cyanide into the mortar constantly while crushing."

Aaron is known to have been an able and painstaking metallurgist, but at the same time these remedies are open to objections. In the first place, several patents have been granted for aprons on which iron bars were placed in various positions and which were expected to aid amalgamation by some galvanic action. The writer experimented with one in the Republic of Colombia, and observed no increased amalgamation or lessened discoloration. The use of zinc amalgam, or indeed of any amalgam containing a debasing, although partially volatile metal, is objectionable. Moreover, when zinc is present in the quicksilver it has a tendency to cause the loss of any floured amalgam.* So far as the use of cadmium amalgam is concerned, it has been recommended by Melville Attwood for dressing plates with the idea of recovering fine gold in the treatment of heavily sulphureted ores, but the writer has failed to hear of any definite results beyond the one quoted by Aaron. It is possible that the cost of the metal—some $2.75 per lb. —and the difficulty of obtaining it in many localities, has prevented its employment on any considerable scale. The use of cyanide of potassium in even dilute solutions, now that its solvent action for gold has been proved beyond question, would seem to involve some degree of risk, although an amalgamated copper plate has the faculty of at least partially precipitating gold from a cyanide solution.

Aaron says, however, that the tarnishing was diminished by the addition of slaked lime to the water. This statement is confirmed by the results obtained at the Star of the East mill, Ballarat, Victoria.† Here a bucketful of lime was added to each ten stamps every two hours, which was found effectual in preventing the formation of a black scum on the plates. The rationale of such an action seems to be the neutralization of acid sulphates in the ore which would otherwise corrode the plates.

The best remedies for this pernicious, and at times persistent, discoloration seem to be a thorough preparation of the plate previous to use, if it is of copper, and constant attention, whether it is of copper or electroplate, after it is in use. The efficacy of any chemical beyond mercury and possibly cyanide of potassium is to be doubted. If there is any quantity of acid salts in the ore, which seem to have a prejudicial effect on amalgamation, neutralization by lime is the cheapest remedy.

Care of Plates When in Use.—The outside plates, that is, those on the aprons and in the sluices, are relieved of the adhering amalgam and the surfaces refreshed with quicksilver and brushing with a solution of cyanide of potassium from once in 24 hours to eight times in the same period, depending upon the local practice. Where the plates become discolored with a scum they have to be cleaned oftener, but under normal conditions there is no necessity of scraping these plates more frequently than once, or at the most twice, in 24 hours. The operation itself is described elsewhere. The amalgamator, when the plates are cleaned, should pay particular attention to the spots on them and should endeavor to eradicate them by prolonged rubbing with a stiff brush and cyanide solution before the mercury is added. When the spots are moistened

* Melville Attwood, *Mining and Scientific Press*, June 24, 1882.
† T. A. Rickard, *Engineering and Mining Journal*, April 29, 1893.

with the cyanide solution they almost instantaneously disappear, only to make their appearance again when the water is turned on. Turning the water on will enable the millman to observe if he has removed the discoloration. If he has he may then apply the quicksilver. If the plates are plain copper it is the practice in many places to remove the spots with a blunt steel scraper, but this is not advisable where electroplates are used.

To most millmen these operations will seem tedious, but it is by exceeding great care only that the growth of the copper stain can be prevented, and these stains mean usually the loss of just so much amalgamating surface.

The inside plates, those on the chuck-block, and at the back of the mortar, are treated only at the semi-monthly clean-up, the procedure being similar to that of the outside plates.

When the plates, both outside and inside, become charged with amalgam too hard to be rubbed off they should be subjected to a process known as "sweating." This is done by heating the plates, preferably in boiling water, when the amalgam becomes softened and can be removed. According to John Hays Hammond, the sweating of the aprons and four outside battery plates of the Empire mill, Grass Valley, Cal., yielded $19,000 after 1½ years' run on $18 ore.

Dimensions of Plates.—Exclusive of the small plates which are sometimes placed at almost every point where the pulp passes into the mill the plates commonly employed are back and front mortar plates, splashboard plates, apron plates, sluice plates and shaking table plates.

Mortar Plates.—Formerly it was the general practice to use two plates inside the mortar, but while this practice is still kept up in many mills, the tendency of modern practice is to use only one, and that at the front of the mortar, beneath the screen frame. Where the back plate is used it is generally bolted by ½-in. bolts directly through the mortar. The plate is countersunk for the bolt and the nut is tightened behind the mortar. The inclination of the feed-mouth of the mortar protects the plates from abrasion by the falling ore. This method is in use in many Californian mills, in Gilpin County, Colorado, and in some of the Black Hills, S. Dak., mills. The reason of its abandonment in mills of modern type is not any inefficiency on its part, but the desire to increase the crushing capacity by narrowing the mortar. The size of this plate depends largely on the dimensions of the mortar. It is usually from 44 to 54 in. long and from 6 to 12 in. deep. The thickness of the copper varies from ⅛ to ¼ in.

The front plate in the old style mortar is bolted to it and is from 44 to 54 in. long, and from 3 to 6 in. deep. That in the modern mortar is fastened to what is termed the "chuck-block," which in the majority of mills is of wood, but in others is of iron plate. These chuck-blocks were formerly made so that the side on which the plate was fastened was nearly perpendicular. This was found to save little gold. The plate is now curved in nearly the arc of a circle over the inside of the block and its top. With the curved block a better discharge is obtained. The depth of plate varies from 3½ to 6½ in. These blocks are made in several heights so that when the dies wear down the insertion of a lower block maintains an almost constant height of discharge.

Splashboard.—This is a board placed in front of the screen and covered with amalgamated plate, or the plate alone may be used. It has an inclination toward

the battery and the pulp as discharged from the screen passes over it. Considerable amalgam is usually caught on this. The size varies, but is frequently 8 by 46 in.

Shaking Tables.—There are several forms of these, similar in principle. Gauthier's is a silver-plated copper table about 4 ft. wide and 16 ft. long. The framework is of iron, and the whole is given a longitudinal oscillation by means of an eccentric. It has been proven to be extremely efficient in collecting amalgam that has passed the sluice plates. Some millmen think it will supersede the apron plate, but its more satisfactory use would seem to be in taking the pulp before it flows on to the concentrators.

Apron and Sluice Plates.—It is almost impossible to specify the size and area of the apron and sluice plates, the variation between different mills is so great. Generally speaking the apron should be as wide as the discharge and the sluice no less wide. As to the length there is considerable difference of opinion. The thickness is from $\frac{1}{16}$ to $\frac{1}{8}$ in.

The following table gives some of the details of leading Californian mills:

TABLE SHOWING PLATE AREA AND PERCENTAGE OF RECOVERY OUTSIDE AND INSIDE MORTAR.

Name of Mine.	Reference.	Screen Used.	Per cent. Amalgamated in Mortar.	Per cent. Amalgamated on Outside Plate.	Area of Apron Plates, Sq. Ft.	Area of Sluice Plates, Sq. Ft.	Total Plate Area.	Loss of Quicksilver, Ozs. Per Ton.
St. Lawrence	A.	Wire 40	Nearly all	.....	15	6	21	.....
Bunker Hill	B.	Slot No. 8	90	10	14	16.3	30.3	0.3
Yuba	C.	Wire 40	90	10	20	56	76	.....
Gaston Ridge	D.	Slot No. 6	85	15	16	36	52	.....
Gaston Ridge	D.	Slot No. 5	50	50	16	36	52	.....
Sheep Ranch	E.	Slot No. 9	80	20	40	133	173	.....
North Star	F.	Wire 30	80	20	24	80	104	1.00
Empire	G.	Wire 30	70—85	25—15	31¼	.....	31.2	1.00
Blue Bell	H.	Wire 30	80	20	20	46⅔	66.6	.....
Washington	H.	Wire 30	65	35	20	46⅔	66.6	.....
Keystone Con.	I.	Slot No. 8	75	25	5	21	26	0.35
Taylor	J.	Slot No. 8	75	25	12	26.6	38.6	1.45
Melton	K.	Slot No. 7	75	25	12	31.2	43.2	.....
Pacific	L.	Pch'd No. 6	70	30	10	16	26.0	.....
Utica	M.	Pch'd No. 9	60	40	96	.....	96	.....
Suffolk	N.	Slot No. 9 or 10	60	40	18	13.3	31.3	.....
Josephine	O.	Slot No. 5, 6, 7	60	40	5.5	34.0	39.5	.....
Plumas-Eureka	P.	Slot No. 8	60	40	25	.....	25	0.27
Delhi	Q.	Slot No. 10	35	65	64	96	160	.....
Stickels	R.	Wire 50	33	67	56	11.6	66.6	.....
Vandalia	S.	Slot No. 8	15	85	16.7	84	100.7	0.57
Spanish	T.	Slot No. 5	60	40	104	24	128	.....

The object of the accompanying table is to show that frequently a high percentage of saving in the mortar is accompanied by a small area of outside plates, and consequently a limited opportunity to save outside the battery, and that the low comparative saving on the outside is due to the small plate area, not to any remarkable efficiency of the mortar. It will be observed that had the writer desired merely to prove his point the table contains data which, had it been omitted, would have accomplished that purpose. It should be remembered that to the ordinary millman in California a high percentage of saving in the mortar presents the idea of good milling, consequently in the returns to the State Mineralogist, from whose reports many of the figures are taken, some may have somewhat overstated the saving. Moreover, in many mills the weights of amalgam from the batteries and from the plates are not recorded, but are guessed at.

The works quoted in the above table, however, are of sufficient importance to lend weight to the figures.

(*a*) The St. Lawrence mine, situated near Ophir, Placer County, Cal., crushes its ores in the old St. Patrick mill, the peculiar features of which are that it saves nearly all the gold in the mortar, and that after the aprons come the narrowest plate sluices in California. These are 5 in. wide. It is not to be wondered that these save little or no gold; the flood of pulp passing through not only fails, except in part, to come in contact with the plates, but washes away any amalgam that may have formed.

(*b*) The Bunker Hill mill, near Amador City, is constructed on more modern principles. The mortar has, for California practice, a comparatively high discharge—7 in. when the die is new. This, as well as the rather fine screen—No. 8 slot, equivalent to 35 mesh—may tend to high amalgamation in the battery. The 90% credited to the mortars includes, however, that collected on the splash-board outside the screen. The plate area, moreover, is much too small.

(*c*) The gold of the soft quartz of the Yuba mine, Nevada County, amalgamates readily, and this as well as the 40-mesh screen may account for the high saving in the mortar, since the plate area is large and the saving as shown by the tailings is extremely good.

(*d*) At the Gaston Ridge mine, Nevada County, an interesting experiment was made which shows the effect of a change of screen on the percentage saved in the battery. With a No. 5 slot screen, one-fourth ton more ore to the stamp was crushed than with a No. 6 slot, but only 50% was saved in the mortar as against 85%. No plates were used in the mortar.

(*e*) The fine screen, No. 9 slot, equal to 40-mesh, and the high discharge, about 9 in., tend to make a high saving in the Sheep Ranch mortars.

(*f*) The North Star, of Grass Valley, is one of the best managed mines in the State, and its mill is thoroughly representative of modern practice. Its plates are wide and long and have sufficient area, it would seem, for any mill, yet John Hays Hammond is quoted as saying that when a Gauthier shaking table was placed below the sluices it saved $50 per day on its 64 sq. ft. of amalgamated plate. This is at the rate of nearly 85c. per ton, which must have passed the plates, and, if saved at all, gone into the concentrates. Tailings assays were made regularly, and such a loss in addition to the unavoidable waste would have been noticed.

(*g*) The Empire ore is very similar to the North Star, but the sulphurets run from $120 to $200 as against $65 to $100 in the North Star. This may be due to the small plate area not saving all the gold or amalgam. In addition, the sluice plates—there are no aprons—are only 16 in. wide.

(*h*) The Blue Bell and the Washington mines, which follow in the table, are under the same management; the ores are almost identical, and the details of milling are the same, yet the percentage saved in the mortars is in the one case 80% and in the other 60%. There is no apparent reason for this, but it seems significant that the sulphurets at the Blue Bell assay $160 to $250 a ton, while those at the Washington run only from $80 to $100. It would seem probable, therefore, that those of the Blue Bell had been enriched by free gold* or amal-

* Free gold used in this sense does not necessarily mean readily amalgamable gold.

gam. The free gold saved at the Blue Bell amounted to $9 per ton, of which $7.20 was saved in the mortar and $1.80 on the plates. The free gold saved at the Washington averaged $7 per ton, of which $4.20 was saved in the mortars and $2.80 on the plates. The concentrates at the Blue Bell averaged $4 per ton of ore crushed, and those at the Washington $1.80 per ton. If we suppose that the natural grade of the Blue Bell pyrites was the same as that of the Washington, there being the same percentage of pyrites in either ore, the saving due to concentration would have been like that of the Washington, $1.80 per ton, and the difference between this and the actual saving, $4 per ton, or $2.20, would have been collected on the plates, making a total amalgamated there of $4, and a total saving by amalgamation inside and outside the mortars of $11.20. The amount saved in the mortar—$7.20 per ton—is 62% of this total saved, so that the corrected percentages of saving would have been 62% in the mortar and 38% on the plates, figures closely approximating the results at the Washington.

(*i*) The Keystone Consolidated is one of the oldest and most successful mines in California, and like all mines where there has been almost uninterrupted financial success, there has been little progress in the milling. Here, as will be observed in the table, the saving in the mortars is 75%, while the outside plate area is only 26.5 sq. ft., 20.5 ft. of which is in double sluices 9 ft. long by 14 in. wide. To show that the saving by the plates is not perfect it is only necessary to mention that a considerable saving is effected by a mercury trap at the foot of the sluices, and that frequently, particularly when running on rich ore, balls of amalgam are found in the Hendy pan concentrators. We can go further than this, however, and quote the values of concentrates. Those from the Hendys assay $96.33, those from the riffle sluice-boxes $71.52, and those from the canvas sluices $44. These figures show the gradual elimination of the gold by purely mechanical means.

(*j*) The Taylor mill, which, it will be observed, has a small plate area of plain copper plates, suffers a heavy loss of quicksilver and, it is thought, of gold also.

(*k*) The Melton mill offers no unusual features, save that its plates are of plain copper and that at times a 50-mesh brass wire screen is used in the battery. Feeding here was by hand.

(*l*) The data given of the Pacific mill at Placerville are manifestly so erroneous that few deductions can be drawn from them. It is said that 15% of the yield came from concentrates, which averaged 0.5% of the ore and assayed $85 per ton. This would mean that the ore ran less than $3 per ton, but it is stated on the authority of Thomas Price that it ran from $6 to $18. The tailings are said to have run from a trace to 75c. per ton. If the saving was as good as this would indicate, amalgam must have been saved with the sulphurets, and the assay of $85 a ton must be considered as being on the pure material.

(*m*) The Utica is a well-managed and successful property at Angel's Camp. Here 40% is saved on the plates, which are 4 ft. wide and 24 ft. long, and silver plated.

(*n*) The ore at the Suffolk is sometimes amalgamated in the battery and sometimes not, according to the percentage of sulphurets. When it is so treated, however, 60% is saved inside, 25% on the apron and sluice-plates, and 15% on an amalgamating shaking table at the end of the sluice. That this shaking table

should save 15% is not strange, since the plate area is not only limited, but the narrowness of the sluice-box—which is only 8 in. wide—must render it of little use in amalgamation.

(*o*) No peculiarities are to be observed in the Josephine mill.

(*p*) The plate area at the Plumas-Eureka mill between the batteries and the concentrators is not large, but the fineness of the gold makes it necessary to employ a considerable number of plates (225 sq. ft. for the whole mill of 60 stamps) after the pulp leaves the concentrators. These plates save only about $300 monthly, and the tailings after leaving them still assay $2 per ton, affording employment to 30 arrastras owned by private individuals. The concentrates, which are treated by pan amalgamation without roasting, yield $25.39 per ton. It seems possible that more could be saved if the sluices, which are only 15 in. wide, were broadened and the area increased.

(*q*) The gold at the Delhi is extremely fine, which probably accounts for the high saving on the large plate area. Tailings here are said to run from 75c. to $1. The ore is said to run over $12 per ton.

(*r*) No copper plates are (or were) used in the Stickels batteries, quicksilver alone being employed. The plate area here is fairly large.

(*s*) The Vandalia is a rather heavily sulphureted ore and the gold is fine. The plates are silver plated.

(*t*) The Spanish mine in Nevada County is one which has obtained great notoriety on account of its low costs of working. The extraction of gold, however, has not been so perfect. The ore here was crushed in Huntingdon mills, each crushing 35 tons daily. This large amount of pulp was passed over quadruple aprons, each apron receiving approximately one-fourth of the pulp. The aprons are 4 ft. wide, the top two are 4 ft. long, the third 3 ft. long, and the fourth 2 ft. The plates being close together the bottoms of the three upper ones assist in amalgamation. There are two such sets to a battery, but no amalgam is found on the second unless the ore runs over 75c. per ton. The gold is fine, for the amalgam from the plates retorts only 20%. In a run of 4126 tons, $2128.33 in gold was recovered, or 51½c. per ton. The tailings during the run assayed 70c., showing an extraction of 42.4%. Part of the loss was unavoidable, doubtless because the ore is crushed coarsely, half being too coarse to pass a 30-mesh screen. A larger plate area might have been beneficial, particularly if the ore was distributed over wide sluices.

Remarks.—It is our conclusion, based not only on the data given here, but on other experiences, that within certain limits, which must be determined for each class of ore, the plate area outside the battery cannot be too great where the ordinary type of quartzose free-milling ores are treated. At the Plymouth Consolidated mine, where there were 98 sq. ft. of amalgamated plate to the battery, a considerable quantity of amalgam was obtained from the plates on the distributing board of the Frue vanners. This has also been observed elsewhere.

Where the plates are silver plated there is danger in having an excess, for the plating is apt to wear off when it is not catching amalgam. The sluices should be of the same width as the apron, and while several drops will aid the amalgamation there should be no diminution in the width until the launders to the vanners are reached. The constriction of the sluice breaks up the wave effect

produced by the splash of the battery, which is believed to aid the amalgamation by the slow rotation of the particles of gold and amalgam. Narrow sluices require an increased grade, the effect of which is referred to elsewhere.

The writer has referred several times to the concentrates containing free gold and amalgam which may have passed the plates. Corroborative of his views is the experience of Dr. R. Goering at the Homestake mill :*

"Two sets of experiments were made in the spring of 1885 by Dr. R. Goering on the Homestake and Golden Star tailings, the first when the mills had no mercury traps, the second after these were introduced. Up to that time there had been collected by means of blankets in a separate building (the blanket house) 1124 tons of concentrates, which assayed $35.16 per ton. These panned down gave 20.5% cleaner concentrates, assaying $40.18 per ton. When amalgamated in the pan they yielded 56.9% of their total assay value, the remaining pure pyrites assaying $17.08 per ton. This shows that the gold recovered must have either been enclosed in quartz or rusty, or that amalgam had been carried off with the tailings and was recovered by the blankets. When, in consequence of these tests the mercury traps were introduced, the loss was reduced. The concentrates then saved assayed $27.63 per ton, showing that while the loss had been diminished it had not been stopped."

It may be remarked here that the outside plate area at the Homestake is about 40 sq. ft.

Where chlorination works are close to the mill the loss on any amalgam or free gold saved in the concentrates is slight, since these add no weight, practically speaking, to the sulphurets and 90% of the assay is paid for. But why take 90% when 100% should have been received? A few feet more of sluices with plates would have accomplished this in most instances.

The following figures, taken from Bowie's "Hydraulic Mining," will illustrate the distribution of gold in the sluices used in hydraulic mining, and if the material operated on differs from crushed quartz, and the method of recovery is at variance with plate amalgamation, they still show that ample opportunity must be given the gold to settle. The figures are from the returns of the Manzanita mine, from Dec. 20, 1876, to Oct. 3, 1877.

	Length of Boxes, Feet.	Pounds of Amalgam.	Per Cent.
Cut	952	353.3	22.6
Tunnel	1,680	561.5	36.0
Long Sluice, First Section	406	63.0	4.0
" Second Section.	784	109.0	6.9
" Third Section	334	37.2	2.3
" Fourth Section.	938	111.5	7.7
" Fifth Section	868	87.0	5.5
" Sixth Section	882	64.0	4.1
Undercurrents	700	172.7	11.0
Total	7,544	1,559.2	100.1

THE ACTUAL WORKING OF A GOLD MILL.

The milling of what are termed free-milling gold ores is a process essentially simple, but which requires, nevertheless, constant care and the practice of all the economies. In silver milling dollars alone are considered ; in gold milling it is a matter of cents and their fractions. That the process has not advanced more, except mechanically, is due to its simplicity, which has placed its conduct,

*H. O. Hofman, "Gold Milling in the Black Hills," *Trans. A. I. M. E.*, Vol. XVII.

as a general rule, in the hands of men who have not cared to make any attempts for advancement, or their multiform duties and the lack of facilities at their command have prevented them from properly investigating the problems which occur.

Considering the process as a mechanical one alone, which it is generally considered to be, economy is the prime factor in successful milling. The cost of everything must be considered; every attempt to save expense of repairs and loss of time must be made. In former days it was the custom to estimate on 300 full working days in the year, and that without the observance of the Sabbath. At the present time a mill which loses 20 days in the year, except for want of ore, is poorly managed. Every superintendent must direct his attention to keeping the stamps dropping, and this cannot be done unless the work is systematically arranged and the results tabulated so that such a check is kept upon every department that any laxity is discoverable at once.

Cardboard blanks must be placed in the mill, so that the man in charge of the shift may enter upon them the stoppages of any particular battery, the cause, and the time lost. Thus a check may be kept upon the comparative workings of the two shifts. Of course, at night in a small mill, where one man alone may be in charge of the batteries, it is excusable to hang up a battery until the morning shift comes on if any important accident has happened. One man alone cannot handle a cam-shaft if a cam has broken, but if a boss has broken, or the stem has broken off, it is his duty to prepare things for the morning shift, so that the repairs can be made in the least possible time, and in the latter cases, after removing the broken parts, to run with four stamps. The latter, however, is a mooted question.

It should be known in advance when repairs due to actual wear should be made and the supplies to make them should be furnished from the storehouse on requisition only. It is bad policy to make the mill the storehouse, except for necessary articles, for it tends to carelessness and extravagance. When the system of requisition is used, with its explanation on the blank of why the demand for the supplies is made, effects can be traced to first causes and the mill accounts more rigidly and accurately kept. The superintendent should make a weekly report to the home office, or to the general manager, specifying the following items: 1. Tons of ore delivered to mill. 2. Tons of ore crushed (estimated). 3. Amalgam recovered from battery (bi-weekly). 4. Amalgam recovered from plates, etc. 5. Lost time. 6. Retort metal (bi-weekly). 7. Bullion melted (bi-weekly). 8. Concentrates saved (tons). 9. Concentrates saved (assay value). 10. Tailings (assay value).

The storehouse should be provided with a blank ruled for a month, on which are printed the articles it contains; on this should be entered everything delivered to the mill. Against this account the requisitions may be held as vouchers. There is no article too small to be entered; passing over a paper of tacks may lead to a shortage in cams.

Screen frames with the screens on them should be kept in readiness in the mill, as should shoes, with the wooden wedges prepared and tied to them. So, too, the superintendent should take the precaution of having duplicate supplies in the storehouse, particularly in a region remote from their source. Neatness

in the interior of a mill tends to careful work. The batteries and iron work should be painted and the floors kept clean. The sweepings from the battery floor when free from oil it is advisable to return to the mortars, as they are liable to contain a certain amount of amalgam.

Labor.—The amount of labor employed in a gold mill is dependent upon its size, its construction, and its motive power. With the ordinary mill (say of 40 stamps), of proper construction, only one man is required on the rock-breaker, one man as amalgamator, and who attends to the batteries, and one man at the concentrators, on each shift. In addition to these is the superintendent, who supervises the clean-up, receives the amalgam and attends to the retorting and melting, and a head concentrator, who looks after the vanners and acts as general machinist. Where the superintendent is in charge of the mine, a head amalgamator is also required. This makes a force of 7 men, not including the superintendent. Three additional men are required if the mill is run by steam-power. The storehouse keeper is usually the bookkeeper of both the mine and mill. A 60-stamp water-power mill may be run with 10 men, but if run by steam four more will be required. A properly constructed 120-stamp mill requires 2 rock-breaker men, 5 amalgamators, 4 men to look after the batteries and oil the machinery, 5 concentrator men, 1 machinist, 1 roustabout, and a foreman—a total of 19 men. Four more men will be required if the mill is run by steam.

The Amalgamators.—It is the amalgamator's duty to look after the plates, feed the proper amount of quicksilver to the battery, and in small mills to attend to the batteries themselves. The plates he should take care of in the manner described in the section on plates. To each battery the quicksilver is fed by means of a small mustard-spoon every half-hour in such quantity that about 1½ ozs. of quicksilver are fed to the ounce of retort metal in the ore. This is generally done by rule-of-thumb or by the appearance and feel of the first outside plate. If he has to take care of the batteries he must look after the feeders, see that they are properly adjusted, regulate the water supply, and have an accurate ear for any unusual occurrence in the mortars. He attends to cleaning the outside plates of their adherent amalgam when on the day shift. This amalgam he cleans in a small hand mill, with the addition of more mercury. The skimmings are saved to be worked in the clean-up pan, and the quicksilver squeezed out. The balls of amalgam are delivered to the superintendent, or locked up in a safe by the responsible party. In large mills, and sometimes unnecessarily in small ones, battery feeders attend to the batteries themselves.

Clean-up.—A partial clean-up of the outside plates is made daily, but once or twice, usually twice, a month there is a general clean-up. In this case, shortly before the day shift comes on, the night shift allows the ore in the mortars to run low by shutting off the feed. At the same time the engine is slowed down. Then the stamps are hung up, the battery water shut off, and after the sand on the apron is washed off with a hose the screens are removed. In the meanwhile the motor is stopped, the screens are washed off on the apron and the amalgam removed therefrom with a scraper. The inside battery plates are taken out and the adhering amalgam scraped off. The lip and the flanges of the mortar are then carefully cleaned of amalgam, and that which has collected during the last

two shifts is taken off the outside plates. All this amalgam is then carefully collected and the sands from the battery shoveled out on the apron. Then the stamps are raised by the traveling block and supported by wooden blocks placed on the fingers, the dies are taken out and scraped of their amalgam, and if worn out are put aside, as they may still contain a considerable quantity of amalgam. The remaining pulp in the mortar is then scooped out and placed with that taken out before the dies were removed. All this is generally put through one battery and that is cleaned up afterward. However, in some mills the practice is to pan down the sands taken out last in gold pans and to remove the iron with a magnet. Then the residue is treated in a clean-up pan or barrel. All of the amalgam removed is treated in one of these with additional mercury. The tailings from the clean-up pan should be returned to the battery, the quicksilver from the clean-up strained in the usual manner, and the amalgam squeezed and retorted.

Advantage is taken of the clean-up to change the shoes and dies and to readjust the drop. If new shoes are to be put on, the old ones are driven out of the boss, and the new ones placed on top of the dies, with the wooden wedges around them. The chuck-blocks or exterior plates are put back and the screen frame placed in position, after some coarse sands have been shoveled around the dies. If the drop has to be regulated blocks of the proper height are placed upon the die and the stamp lowered until it rests upon them, then the tappet is loosened until it rests on the finger. It is then keyed up.

The care of the plates is an important feature of the clean-up; they should be relieved of their amalgam without injuring their surface. When the amalgam is taken off fresh quicksilver should be placed upon them and they should be carefully scoured and brushed. The time required for a clean-up varies from 5 to 7 hours. All the hands of the mill should take part in it; if the mill is large, even the night shift, who thus work an extra shift and then usually change with the day force.

Concentration.—It is outside of the scope of this article to treat of concentration in more than a cursory manner. It may be said that in few gold mills is the sizing of the pulp followed—a prime requisite in the concentration of other ores. This could be easily effected by sizing boxes or pointed boxes.

Frue vanners and the Triumph and Hendy traveling belt machines have been very satisfactorily employed to concentrate the auriferous sulphurets. These are machines which require little care, so far as their mechanical features are concerned, but the manipulation of them should be carefully watched. The regulation of the amount of water flowing on them is an important feature, as is the rapidity of the side or end shake. The depth of the pulp on the belt should not be too great. This can be regulated only by using more machines, or less advantageously by changing the inclination and speed. The common practice with ordinary ores is to employ two machines to each 5-stamp battery. Where the ores are heavily sulphureted extra belts are sometimes required. On the distributing board of the Frue vanner an amalgamated plate is placed, and on the Triumph there is a bowl filled with quicksilver through which the pulp passes. These devices save some additional amalgam, as does the belt itself.

The sulphurets on the vanners are washed off by passing through a water tank

and by a jet of water playing on the belt. The overflow from this tank should be allowed to settle carefully, as it may contain the finer sulphurets, which in some ores are much richer than the coarser which readily settle. As the ore from different portions of the same mine may contain varying proportions of sulphurets, ranging from a fractional percentage to 5% or 6%, it is well to conduct all the pulp in one conduit to the vanner floor and there distribute it. In this way it is mixed and each machine receives similar pulp, which it may not when it is taken directly from the batteries to the machines. The conduits are oftentimes iron pipes, and while they are more sightly and less prone to leak than sluices, an incrustation forms in them containing considerable gold which cannot be removed readily. Where there is over 6% of sulphurets in the ore, the shaking table is to be preferred. The Gilpin County concentrator is a favorite example of these.

Assay of Tailings.—It is considered a desirable thing in almost every business to know just what one is doing, but in gold milling most millmen are content to close their eyes to actual results. Assays of tailings are rarely made; indeed, few mills are provided with the facilities for making them. They should be made regularly, however, and the samples should be properly taken. Frequently they are collected at the discharge end of the vanner. This sample is erroneous, as the dish usually employed, on account of its shape, will not catch the pulp which passes down the side near the flange, and which is the richer portion of the tailings. The only proper sample is taken by periodically catching the whole stream and allowing everything to settle. In addition the tailings should be examined microscopically to see if any gold is carried away mechanically enclosed by the gangue.

Losses in Milling.—A preceding paragraph has shown that there are possibilities of great losses in gold milling. When, however, the ore is suited to the process; that is to say when the gold cannot help being caught, the results are remarkably good. Careful assaying at the North Star mill, Grass Valley, Cal., showed that 82% to 94% of the gold in the ore, calculating from the value of the tailings and the gold saved, including the concentrates, was returned by the mill. At the Plymouth Consolidated the average result was about 90%, figured in the same manner. There are other mills in the State whose tailings have run over $6 when the ore was milling about $8. In the Black Hills it is claimed that 85% is saved by the mills of the Homestake Company. At the Plumas-Eureka mill, Plumas County, California, a little more than 80% is saved. These results are on typical free milling ores.

Amalgam.—Mercury combines with gold in definite proportions as well as taking it into solution. Several crystalline amalgams have been observed, all of which are in the isometric system. The octohedral amalgam contains nearly equal proportions of gold and mercury and is the one commonly found inside the mortars. The prismatic and acicular amalgams contain from 30% to 20% gold and are readily taken into solution by an excess of mercury at a comparatively low temperature. The amalgams found in gold mills vary in the proportion of gold they contain, those from inside the battery being the richest, as the gold is coarser and less perfectly amalgamated. Where the gold in the ore is fine the percentage of retorted gold is lower. Battery amalgam on ores of

comparatively coarse gold should average 40% to 50%, but cases are known where the retort was as high as 70%. Fine gold may make an amalgam in the mortar running as low as 20% gold. That from the outside plates is invariably lower than that from the mortar, and indeed if plates, wells and blankets are used successively, the amalgam varies in its gold contents with each. The further away from the battery the less gold is found in the hard-squeezed amalgam. So, too, when an experiment was made in cleaning up each strip of copper plate separately, retorting the amalgam separately and assaying the resultant bullion, the percentage of retort was found to decrease from 45% in the battery to 27% on the distributing boards of the Frue vanners. In addition, the fineness of the bullion decreased regularly from 800 fine to a little over 700, each clean-up being a little baser than the one above it.

Calculations from figures given by T. A. Rickard* show that at the Port Phillip mine, Victoria, Australia, the percentage of retort in the amalgam varied in the same way, that from the mortar clean-up running 45.2%. from the mercury wells 35.2%, from the blankets 29.7%, and from the Chile mills, where roasted concentrates were treated with an excess of mercury, some 25.1%.

A peculiarity of amalgam is that it contains more gold in winter than in summer. This is due undoubtedly to the warmer water in summer making the amalgam more fluid. The difference ordinarily is slight. Amalgam that retorts 40% in summer may retort 45% in winter.

Retorting the Amalgam.—In gold mills of large size retorts similar to those employed in silver mills are used. In smaller mills the cup-shaped retort is used. With these the interior is lined with chalk or thin paper and the amalgam crushed down; the top is then luted on with a mixture of clay and ashes. The amalgam is placed in trays coated with a little chalk or clay for the large retorts. The heat at first is low, but is gradually raised. Care must be taken that the outlet is clear or an explosion may take place. Retorting occupies from 2 to 4 hours.

The retorted amalgam is broken into pieces and melted in an annealed plumbago crucible with the addition of a little borax. Nitre is also used if the bullion contains base metals. The skimmings and the ashes from the retort must be saved and panned as they frequently contain gold. Melting 1000 ozs. of bullion will not take over 2 hours in a good-sized furnace.

Care of Quicksilver.—The loss of quicksilver varies from less than 0.1 oz. up to 1½ ozs. per ton of ore. This loss in unusual quantities may be due to impurities in the quicksilver itself or to some of the constituents of the ore. It has been pointed out that certain sulphides and certain metals, notably bismuth, copper, or lead, if present, cause a loss, or it may be due to mechanical reasons, such as too fine stamping, or again to carelessness in manipulation, such as overfeeding the mercury or keeping the plates too wet, *i. e.*, too thoroughly amalgamated. Many of the causes which tend to the loss of gold effect a loss of mercury. Indeed both are generally lost together.

It is well to retort the quicksilver occasionally, as when it is charged with any other metal its affinity for gold is lessened. Straining does not remove all of the

* *Engineering and Mining Journal*, Jan. 28, 1893.

gold by any means, nor all of the baser metals. The quicksilver, if sluggish, can be cleaned in the clean-up pan by first adding to it a small quantity of sodium and removing the scum which rises to the surface, and then adding a strong solution of caustic soda or potash. Cyanide of potassium is also an active agent for cleansing quicksilver.

AMALGAMATION OF GOLD ORES IN MECHANICAL APPLIANCES.

Amalgamation in Tyrolean Bowls.—This is the simplest form of pan amalgamation. The mills are about 24 in. in diameter at the top, 16 in. at the bottom, and about 9 in. high. They are made of cast iron, not in the direct form of a cone, but with a step 3 in. wide on the side. Over the step is a block of wood 1½ in. less in diameter than the pan, and which is hollowed out at the center, where the pulp is fed. On the bottom is a layer of quicksilver 1 in. deep, over which the pulp passes. The operation is continuous and the pulp usually passes through a series of the bowls.

If the ore contains a large percentage of pyritic material it is concentrated previous to amalgamation, otherwise it is amalgamated direct, 75% being saved at one operation and 15% more by a repetition, a total of 90%. As mentioned elsewhere, the process is inadequate to save gold alloyed with any considerable percentage of silver.

Amalgamation in the Arrastra.—The arrastra still has its advocates who commend it as a close saving apparatus, the drawback being its small capacity, few grinding more than from 1200 to 1500 lbs. of quartz in 24 hours, even where the ore is previously crushed to the size of a hazelnut by a Chilean mill. In working with the arrastra it is partially filled with the crushed pulp, and a small quantity of quicksilver added. As the grinding proceeds, pulp up to 1500 lbs. is added from time to time. It is made to revolve slowly, but finally it is driven with increased speed. It is customary to grind a few tons of poor ore before the high-grade ore is added in order to fill the cracks and to prevent the escape of gold amalgam, which is caught in the bottom. Before the charge is drawn off water is added to thin the pulp, when the suspended amalgam sinks to the bottom. This and the sulphurets are collected and separated by washing when the periodical clean-up is made. Results on mixed gold and silver ores show that 40% only is saved. However, the results on purely gold ores are better, but not to the extent that some writers have claimed. It is possible to extract 90% from such ores by the arrastra, but only by long-continued grinding, when the cost becomes too high. The cost in Mexico for grinding for the patio process, in the arrastra, without any special reference to amalgamation, is from $1 to $1.50 per ton. C. A. Stetefeldt claims* that the arrastra is the best amalgamator, as it grinds more thoroughly and finely, and, other things being equal, the amalgamation depends upon thorough grinding. At the Bote mine in Zacatecas, where arrastra amalgamation is practiced on a mixed gold and silver ore with, it is claimed, excellent results, the opinion is advanced that the silver amalgam which is added to the arrastra in lieu of quicksilver forms a coating on the stone bottom, making it similar to an amalgamated plate.

* *Trans. A. I. M. E.*, Vol. XIV.

Arrastras somewhat different in character are frequently used in California for the reduction of cement gravel, drift gravel, or the treatment of the coarser sands flowing from gold mills. These are from 12 to 20 ft. in diameter and about 3 ft. deep. The bottoms are of rocks roughly dressed but so laid in cement as to present an even surface. The drags, which are made of the toughest rock procurable, are suspended from arms which are carried on a thick post placed in the center. They are driven either by belt and pulley or by a spur and pinion gearing. The drags weigh from 1200 to 1600 lbs. and are so suspended from the arms that they pass over all portions of the bottom when the arrastra is in operation. When working on gravel the usual charge varies from 5 to 9 tons. With tailings the charge is less, as the grinding has to be finer. The same precautions in charging as previously spoken of are observed. If cement gravel is treated an hour's grinding is considered sufficient, but if quartz sands are being reduced they must be ground 24 hours at least.

The amount of quicksilver used is dependent upon the richness of the stuff treated, but is kept at a minimum, so as to form a hard amalgam. In the case of tailings the amalgam is retained in the arrastra until a clean-up is made, but with cement or other gravel, amalgam and pulp are discharged through a riffle-sluice which catches the alloy of the precious metal. With gravel the discharge is through a movable gate which extends to the bottom; with tailings it is through plug-holes, water being added while drawing off the charge. Working on cement gravel the capacity of this arrastra is said to be 50 tons daily, and as high as 90 tons on soft top gravel.

The Direct Amalgamation of Pyrites.—This has been attempted at various times but without any marked success. The nature of the pulp is inimical to amalgamation, yet a combination of Chilean mills, amalgamating "dollys," and sets of Tyrolean bowls, which was called the "Rosales Mechanical Process," was at one time in operation at the Walhalla mine, Victoria, Australia, treating pyrites. It was claimed that the results on raw pyrites were better than those on roasted ore. The process was a failure, however, on the pyrites of an adjoining mine. Sodium amalgam and the use of caustic soda were features of this process.

At Port Phillip, Victoria, experiments were made by J. Latta by the direct amalgamation of pyrites concentrates in arrastras, with a stream of water running through continuously. He found that on ores assaying $66 per ton 29.21% was saved, 42.84% was left in the tailings, and 27.95% was carried away in suspension by the water. The loss of mercury was heavy.

At the Ready Relief mine, San Diego County, California, auriferous pyrites assaying $100 a ton were treated in arrastras without previous roasting and only $15 per ton was extracted. Experiments made on the direct amalgamation of pyritic ores from the Manter mine, Placer County, California, in a wooden-bottomed settler, after the ore had been subject to a long grinding in pans, resulted in an extraction of from 50% to 60%. By free amalgamation over plates 25% was extracted. It was claimed by the management of the Plumas-Eureka mine, California, that 83% was extracted from concentrates treated raw in pans.

Amalgamation of Pyritic Ores After Roasting.—It is reported that at one period heap roasting before amalgamation in the stamp mill was practiced at Clunes, Victoria, Australia, but no results are obtainable of such practice if it

existed. Kilns have, however, been used in various localities, notably at Murphy's, Calaveras County, California, where a large circular-stack furnace was used. A Baker blower was attached to the furnace. The pulp, crushed through a 30-mesh screen, was mechanically mixed with sawdust and a certain amount of water. The roasting was completed in from 2½ to 7 hours. Pan amalgamation was tried on the roasted pulp, but chlorination was eventually adopted.

At the San Guiseppe mine, Tuolumne County, California, coarse ore was charged with wood into a cupola furnace and roasted 48 hours. The ore ran from $32.50 to $60 a ton, $20 to $40 of which was saved by amalgamation in an arrastra, while nothing could be saved without being roasted.

At a small mine in Shoshone County, Idaho, $20 ore was treated in arrastras after a heap roast, and it was said by the owners that the results were far better than by direct amalgamation. A sample of the richer ore showed globules of gold on the surface of the quartz after roasting, so that the ore probably contained selenides or tellurides* as well as pyrites.

At El Oro, State of Mexico, Mexico, at one time the coarse ore, which contained 3% to 6% pyrites and which was amalgamated in pans, was roasted in kilns, and the results were no better than with raw amalgamation, so that this modification of the ordinary process was abandoned after a thorough trial. The results by ordinary pan amalgamation here averaged a little over 70% on a year's run. The ore contained, however, a considerable amount of silver.

Pyrites concentrates have been frequently treated, and are still being treated, in a number of localities by pan amalgamation after a thorough roasting in a reverberatory furnace. The results as a general rule are much below those which could be obtained by chlorination and the costs are as high.

Roasted pyrites treated at reduction works at Sacramento, Cal., in early days, yielded from 80% to 90% by pan amalgamation.

At Marmora, Canada, according to R. P. Rothwell, roasted arsenical pyrites treated in large quantities in pans yielded 84%.

The concentrates of the various mills at Clunes, Victoria, Australia, have been treated successfully, after roasting in reverberatory and mechanical furnaces, by amalgamation in a Chile mill. As high as 95% was obtained on long runs, and single charges were said to have frequently yielded at the rate of 98%. Large quantities of mercury were employed, with a corresponding loss. The success of the process is said to be dependent upon the consistency of the pulp; it must be merely damp. At various mills in Australia amalgamation in pans after roasting has been adopted, with average results as high as 90% to 97% at the Harrietville mill, Victoria,†

Some years ago C. A. Stetefeldt made a number of interesting and instructive experiments on the ores of the Los Minas, Vera Cruz, Mexico.‡ These ores are of a variety not at all common in the United States, and present considerable difficulty in treatment. They are magnetite with pyrite, chalcopyrite, quartz and garnet. They contain a trace of zinc and lead, and run from 43% to 67% magnetite, 3.5% to 7% pyrites of copper and 3% to 22% pyrites of iron. The gold contents varied from $6 to $16 per ton, though it could be seen only in

* This result has been observed after roasting ores containing selenide of gold at least.
† According to T. A. Rickard. ‡ *Trans. A. I. M. E.*, Vol. XIV.

extremely fine particles after pulverizing and washing. They contain practically no silver.

Stetefeldt made a number of experiments in roasting with and without salt, in which he proved that with a chloridizing roast there was a large loss of gold, and that an oxidizing roast left a large percentage of magnetite intact. His attention was then given to amalgamating the ore, and his deductions in this regard were from experiments in an ordinary flat-bottomed iron mortar, which was supposed to represent more accurately the action of the pan, and in a wedge mortar, which simulated the arrastra. Without describing his experiments in detail his conclusions were substantially as follows: The ore should be given a quick oxidizing roast; when copper enters the amalgam the extraction is decreased; the amalgamation of finely divided gold requires friction—the contact with quicksilver alone is not sufficient; the quicksilver should be charged with a certain percentage of gold or silver previous to use; the arrastra is by all means the best amalgamating apparatus, as it grinds better and quicker, and the result of amalgamation, other things being equal, is dependent upon the grinding efficiency of the appliance used; the amalgamation of gold-bearing silver ores which have been chloridized is not feasible in an arrastra.

Stetefeldt claimed to have rediscovered by his analytical researches that the arrastra is the best amalgamator known. This, he says, has long been known to the Mexicans, though the statement is to be doubted, as the adoption of the arrastra by the Mexicans at their comparatively few gold mines was, and is, due principally to local conditions and lack of money. The patio process is universally adopted, as it adds no iron to the pulp to consume the magistral, or sulphate of copper, and at the same time it saves from mixed gold and silver ores a considerable but not a high percentage of the gold.

The Designolle process of amalgamation with a solution of bichloride of mercury was given a fair trial and then abandoned, for reasons which will appear, at the Haile mine, South Carolina, according to E. Gyffon Spilsbury.* This process is now being used, it is said, on a small scale in South Africa. At the Haile mine the process adopted was as follows: After an oxidizing roast the ore was placed in charges of 600 lbs. in cast-iron barrels containing 1000 lbs. of cast-iron balls. The barrel was partially filled with water and ½ gal. of the bichloride of mercury solution added. The solution was formed by the addition of 8 lbs. of mercury to 64 gals. of water. One gallon of this was sufficient for a charge of ore containing under ¾ oz. of gold to the ton, but ½ gal. was added for each additional ½ oz. per ton. After the addition of the first ½ gal. of solution the barrel was rotated for 5 minutes, then the second ½ gal. was added. The barrel was then revolved for 15 minutes, when the amalgamation was considered complete. The contents were then discharged into a settler having a bed of mercury on its concave bottom. The discharge from the settler passed over revolving centrifugal copper plates, which caught the suspended amalgam and then passed into a second settler. The process, although the cost, including everything, was only 35c. a ton, was discontinued, as with the increased grade of the concentrates, owing to improved methods of concentration, the extraction was less perfect.

* *Trans. A. I. M. E.*, Vol. XII.

However, 87% was easily obtained. By this time the barrels had been replaced by pans and settlers, but the trouble lay in the production of large quantities of oxide of iron, which became amalgamated. The resultant mass proved harder to treat than the ore itself. By repeated washing, settling and regrinding with fresh mercury it could be partially cleansed, but not without a loss of gold.*

While the process was in operation at the Haile mine the composition of the standard solution was as follows: Bichloride of mercury one part; salt two parts, and hydrochloric acid one part. The percentage of the acid, however, varied with the so-called rustiness of the gold. Salt being present, the reaction which occurs is considered to be as follows:

$$Hg\ Cl_2 + Fe = Fe\ Cl_2 + Hg.$$

Mercury is reduced to the metallic state and amalgamates with the gold. Or if salt is not present:

$$2Hg\ Cl_2 + Fe = Hg_2\ Cl_2 + Fe\ Cl_2.$$

Then:

$$Hg_2\ Cl_2 + Fe = 2Hg + Fe\ Cl_2.$$

The bichloride of mercury is first reduced by iron to calomel or mercurous chloride, which is reacted upon by the iron, with formation, as before, of metallic mercury. As the calomel is insoluble in water the latter reaction would probably cause a loss of mercury, so it is advisable to have salt in the solution. Ordinarily the composition of the bichloride of mercury by iron is a slow process, but here it seems to take place rapidly. As $43 ore amalgamated perfectly in 10 minutes Spillsbury thinks that an electrolytic action between the iron, mercury and gold takes place in the acidulated solution.

A number of attempts, without marked success, have been made to amalgamate gold ores with solutions of salts of mercury. Nitrate of mercury has been so tried, and although it is possible to reduce it to fine globules by iron, it has met with no satisfactory application.

C. H. Aaron recommended the use of cyanide of mercury in solution with cyanide of potassium in the pan amalgamation of gold ores. This is claimed to give good results. The solution, he said, should be made alkaline by addition of caustic potash or soda.

AMALGAMATION OF MIXED GOLD AND SILVER ORES.

These ores are those commonly found in the United States, Mexico, and other countries, which, failing to give good results by free plate and battery amal-

*This amalgamation of iron has been noticed in the pan amalgamation process known as the "Washoe Process," where sulphate of copper and salt are employed. In the case of a Nevada mine the results by extraction were good, but the amalgam and bullion were difficult to treat. The fusion of the retorted amalgam with large quantities of niter only partially removed the iron in the slag. According to J. C. F. Johnson, of Adelaide, Australia, the amalgam from a West Australian mine contained nearly 70% of impurities, principally iron, owing to the presence of arsenite of iron in the ore and large quantities of calcium, sodium and magnesium chlorides in the mine water used for milling. This water showed the following contents in grains per gallon: Carbonate of iron, 2.76; carbonate of lime, 7.61; sulphate of lime, 81.71; chloride of lime, 2797.84; chloride of magnesium, 610.13; chloride of sodium, 5072.65; the total solid contents were, therefore, 8572.7 grains or 19.5 ozs. to the gallon of water. This is not only interesting on account of the effect of impure water, but on account of Mr. Johnson's successful treatment of the ferruginous amalgam. He placed 1583 grains of it under a powerful press, which expelled 383 grains of mercury. The result was a dark-gray friable mass. This he powdered and retorted. The retort was brown, but after being roasted on a flat sheet of metal became russet-colored and weighed 510 grains. On smelting this with borax the iron oxide went into the slag, and the resultant bullion, which weighed 311 grains, assayed 871 fine. A second smelting brought the bullion up to 914 fine.

gamation, are treated raw in pans. The Comstock ores are of this class, and here it was that the modern pan practice originated. These ores are typically free for this process. They contain various sulphides of silver, which are easily reduced by the aid of the chemicals employed and the iron of the pan, metallic gold and silver, and some chloride of silver. The gold is believed to be mainly in the metallic state. The results vary even on the Comstock; ore from one mine will not give as good results as that from another, due probably to the varying influences of the gangue matter. Almost invariably, however, the extraction of the gold has been better than that of the silver. Thus at the Hale & Norcross mine, on the milling of 299,929 tons of ore, the extraction was 76% gold and 61% silver. At the Savage it was nearly the same—76.3% gold and 62% silver. In regard to the extraction, it must be remembered, however, that no particular attempt was made by the management to mill closely, as the tailings were perquisites of the men who controlled the mill. It has been proven by elaborate experiments on a large scale at the Gould & Curry mine, then under the management of Louis Janin, Sr., that very much higher results could be counted upon when working these ores. In these and other experiments conducted by Louis, Henry and Alexis Janin, which extended over years, the efficiency of the "Washoe Process" of using sulphate of copper and salt on these and many other ores was demonstrated beyond doubt for the first time. It may be taken as a metallurgical axiom that the metal which is saved by the mere repetition of a process should properly have been saved at the first operation. So that a portion at least of the 76.28% gold and 87.06% silver which was saved at the Janin mill from Savage slimes* should properly have been saved at the first operation. These results show, however, that slimy ore is inimical to the amalgamation of gold as compared with that of silver. This was almost universally observed on the Comstock.

The results on this class of ore differ with the composition. The ores of the Minas Prietas mine, Sonora, Mexico, yielded on an average about 75% of gold and 10% silver, while the gold and silver contents were nearly equal in value. The ores of the Ida Elmore and Golden Chariot mines, of Owyhee County, Idaho, yielded about 95% of either metal. Those from the De Lamar mine in the same vicinity yield about 83% to 85% at the present time. At El Oro mine in Mexico the yield is some 70% on an average. From the ores of the Bodie Consolidated mine, Bodie, Cal., which had an average assay value of $39.11 gold and $31.03 silver, it was claimed 94.17% gold and 75.83% silver was returned by the pans. At the Cambria mill in the Thames district, New Zealand, where an ore containing both gold and silver is treated on amalgamating tables and in Berdan pans, the following results were obtained :† The ore assayed 7 ozs. 18 dwts. 19 grains gold and 9 ozs. 14 dwts. 2 grains silver to the ton. Only 3.3% was obtained on the tables and 48.2% in the pans, a total of 51.5%. This is supposed to be one of the best mills in the district.

Method of Working in Pans.—On account of the limitation of space it is not possible to go into details on this subject, but, other things being equal, the closeness of extraction of mixed gold and silver ores in the pans depends upon: (*a*) The fineness of pulp; (*b*) the time of adding mercury; (*c*) the consistency

* Slimes from pans, not from batteries. † According to T. A. Rickard.

of the pulp; (*d*) the period of amalgamation; (*e*) the amount of mercury employed; (*f*) the chemicals used; (*g*) condition of mercury; (*h*) the perfect working of the settling apparatus.

(*a*) As in plate amalgamation, the ore must be crushed fine enough to free the gold from the gangue. Where pan amalgamation is employed, in order to increase the crushing capacity of the battery, and to prevent the formation of undue quantities of battery slimes, this is accomplished by grinding in the pan itself, usually for two hours. The pulp from most ores at the end of this time will be fine enough to pass a 60-mesh screen, and most of it in an impalpable powder. As in crushing for plate amalgamation, this grinding must not be carried too far, as the slimes produced will exert an unfavorable influence on amalgamation. The length of time the ore should be ground, if ground at all, must be determined by experiment. It is folly to work an ore on preconceived notions derived from other localities. When chemicals are used the ore is usually ground with them.

(*b*) To mention the time of adding the mercury would seem almost senseless had the writer not seen several mills where grinding was in practice, and where the mercury as well as the ore was ground. This, of course, so flours the mercury and amalgam that no settling apparatus can collect them.

(*c*) It has been proven that a thick pulp works better than a thin one, which is natural, as the mercury thrown up by the muller remains longer in suspension in the pulp; with a thick pulp also more ore can be worked at a charge. The rule-of-thumb method for determining the proper consistency is to dip a stick in the pan. The pulp should coat it thickly and drop off sluggishly.

(*d*) The period of amalgamation varies from 6 to 8 hours. The proper time must be determined for the special ore. If the amalgamation is complete at the shorter period it is a saving of power and an increase of pan capacity to discharge it without waiting longer, but nevertheless it is important to give full time.

(*e*) The amount of mercury employed varies, on ores containing much gold, from 50 to 300 lbs. We prefer to use a large quantity, divided into two portions, the second introduced when the time of amalgamation is half completed. The objection to the large quantity is that the loss of mercury is somewhat increased and a much larger quantity of this expensive metal must be carried in stock.

(*f*) The chemicals employed on mixed ores of gold and silver are mainly for the purpose of aiding the amalgamation of the silver, not that of the gold. Yet while it is not clearly proven that certain chemicals have any beneficial action on gold amalgamation in pans, there are some instances where their effect at least seems beneficial. The days of the reckless employment of any chemical have gone by, and in the list of the millmen there are but a few such agents, some of which have a favorable action upon quicksilver alone. Some years ago the Patchen process attracted some attention on the Comstock; it consisted in mixing the ore with certain chemicals, including the subchloride of copper, in a wood or copper-lined pan, provided with a heating chamber. Amalgamation itself took place in a second pan. The published results on Belcher ore showed an extraction of as high as 94.7% to 99.3% of the gold and from 91% to 95.9% of the silver. These results were much higher than those commonly accredited to the Washoe process, but there were difficulties in the way of success. The sub-

chloride of copper was not only expensive to manufacture but it was unstable, readily decomposing, and the product of decomposition had no beneficial effect on amalgamation. It would appear, however, that the action of this recognized powerful chloridizing agent was as marked on gold as on silver. Where the gold and the silver are contained in the same mineral there can be little doubt that where the silver is chloridized and amalgamated some of the gold will go with it. Up to the present time nothing has been found more beneficial than sulphate of copper and salt.

(*g*) The condition of the mercury, as in battery-plate amalgamation, has considerable to do with success. The methods mentioned there can be followed in pan amalgamation, though in the latter process the operation of cleansing takes place in the clean-up pan, and in this case it is not so absolutely essential to have almost chemically pure mercury. An experience in treating a silver ore at the Ontario silver mine, Utah, might be easily paralleled at a gold mill. Here the mercury in the mercury storage tanks was constantly coated with a black, greasy scum; after various experiments in the clean-up pan were made, this finally disappeared, however, after a small quantity of zinc, amalgamated with the aid of sulphuric acid, was added to each pan charge. When zinc is added to mercury under a covering of dilute sulphuric acid, hydrogen is evolved and the cleansing action is similar to that caused by sodium amalgam.

(*h*) Upon the perfect working of the settling appliance is dependent the collection of the mercury and amalgam, and this working depends mainly upon construction, through to a certain degree also upon the amount of water employed when discharging. An agitator should be placed below the settler, and riffle-sluices below this are sometimes found to save a considerable amount of amalgam. The Rae electric process, which consists in placing copper wings in the settler, which form the positive terminals of an electric current, the iron bottom being the negative, saved considerable silver amalgam at the Christy mill, Silver Reef, Utah. Good results were also obtained at the Drumlummon mill, Montana.

Amalgamating Ores Containing Gold and Silver After a Chloridizing Roast.—The objection to this method of treatment is the loss of gold which is entailed in the roasting. This loss has been clearly proved time and again at various mills. It is minimized, probably, in the reverberatory furnace, as the results at Dall's Washoe mill on high-grade Comstock ores, and those of the Mexican mill on ores of that mine prove. This furnace is debarred, however, from working low-grade ores on account of the cost of the operation.

Conclusions.—In reviewing briefly the various methods spoken of in the preceeding section it may be said that the first method spoken of—amalgamation in Tyrolean bowls—is entirely inadequate to modern wants. The arrastra, the writer is inclined to believe, is an overrated device. There are few recorded instances of the superiority claimed for it above the ordinary milling process, and its slowness would, under most circumstances, disqualify it for use. The results of the mechanical arrastra at Pastarena are good, and this type of machine is well worth consideration.

The direct amalgamation of pyrites is out of the question, and that of pyritic ores after a heap, stall or kiln roast would seem little better. The amalgamation in pans of roasted pyritic concentrates is entirely feasible, so far as a fair extrac-

tion is concerned, but it is certain that where there is any considerable quantity of these it is profitable, on account of lessened costs and increased extraction, to chlorinate after roasting. There can be no question that where there is a mixed silver and gold ore, pan amalgamation is the proper process, as far as our present knowledge of metallurgy goes. The loss in the chloridizing roast is the sole objection to the method of roasting and amalgamating rebellious ores of gold and silver.

The Hydrogen Amalgam Process.—This process, sometimes known as the Molloy process, is dependent upon the production electrolytically of hydrogen, its absorption by mercury, and the supposed greater affinity of mercury containing hydrogen, or kept "active" by it, for gold. The apparatus consists of a shallow pan, 1 in. in depth and 3½ ft. in diameter. Mercury is placed in the pan to a depth of ½ in. In the center of the pan a porous jar is so placed that the mercury cannot enter it, containing a solution of caustic soda and a lead cylinder. This cylinder is connected with the positive pole of a small dynamo, and the mercury with the negative pole. When the current passes the caustic soda is decomposed, with evolution of oxygen, which attacks the lead and hydrogen, of which a portion is amalgamated. The pulverized ore is brought in contact with the mercury by means of a revolving disc. The process has not been successful in this country; but it is claimed by the inventor that 10% more is extracted by this than by the ordinary method.

The Combination Milling Process.—This process for milling gold ores containing silver was first introduced at the Drumlummon mill of the Montana Company, Limited, at Marysville, Mont. Here the ore was passed over plates after leaving the battery, then over Frue vanners, thence into settling tanks, from whence it is shoveled into pans and amalgamated by the usual process. The object of the plates is to catch any free and easily amalgamable gold. The Frue vanners serve to concentrate the heavier sulphurets and the pans to amalgamate any chloride of silver or difficult concentratable minerals. Results at the Drumlummon showed that finer bullion was produced and the loss of mercury was reduced from 1.55 lbs. per ton to 0.62 lb. The calculation has been made, accounting for losses by all the processes and assuming that $25 gold and silver ore is to be treated, that the net profit by selling to smelters would be 25c., that by chloridizing, roasting and amalgamation $9.50 a ton, and that by the combination process $16.50. These calculations were made by interested parties, and possibly deductions should be made from the estimate, but that that process presents excellent metallurgical features there can be no doubt. It is eminently logical, particularly, to separate the heavy sulphurets, auriferous, argentiferous or otherwise, from the pulp before it is sent to the pans. These sulphurets naturally tend to the formation of base bullion, and, moreover, they flour the quicksilver, as has been shown. The process has certain limitations, however. It must not be supposed that every rebellious ore containing gold and silver now being treated by amalgamation after roasting can be reduced more successfully by this process. On the contrary, there are some ores which contain such percentages of heavy yet comparatively valueless minerals, that the vanner, or several vanners, would not be able to stand the load, and moreover the silver in the concentrates would practically be lost owing to their low grade. The ore best suited to the process

is one that contains not more than 3% of sulphurets—less than this percentage is better—and which has a clean quartz gangue.

The Boss Continuous Process.—This process of passing the pulp directly from the battery through a series of amalgamating pans is in seeming contradiction to the theory advanced on a previous page, that successful amalgamation requires a thick pulp, as it does in charge pans; but the Boss system works on a different basis. It may be compared to a long line of copper-plate sluices as compared with a deep mercury trough. The thin pulp in passing through the Boss pans actually comes into contact with more quicksilver than it would if of the same thickness in a charge pan.

The Boss system has been remarkably successful in a number of mills. It has numerous advantages. Tank shovelers, many of the panmen and carmen, in many mills, are done away with. The loss of quicksilver is frequently less. Automatism is the direction toward which all branches of metallurgy are tending, and this furnishes it in what is ordinarily the clumsiest metallurgical plant, the wet-crushing, free-milling gold or silver pan mill. And moreover the cost of milling is lessened.

In this process the pulp flows directly from the batteries to the grinding pans. Two of these mills treat the pulp from a 10-stamp battery, but if the ore requires, it may be passed through more. After these comes the chemical mixer, if chemicals are used. This is a large pan; in fact a settler lined with wood on the sides. Here the pulp is retained for a considerable length of time. The pan is fitted with a steam bottom and the chemicals are fed automatically by a feeder devised for that purpose. The amalgamating pans are below this. These are similar to the ordinary pans in many ways. Two settlers are provided for each line of pans.

It will be understood that the ore in a well-constructed Boss mill requires no handling after it has left the rock-breakers. The Boss process may be summed up as being admirably suited for the free-milling chloride ores or for ores with a clean gangue and carrying the gold or silver in an easily reducible state.

Conclusion.—The statements given in this article of past experience in amalgamating gold ores will show the steps which have gradually led up to the adoption of the various methods now most generally in use. They will also show that there is room for improvement in our present practice, and will, perhaps, help to indicate the lines on which such improvement is to be looked for in the future.

GRAPHITE.

THIS mineral, also called plumbago, is found in many parts of the world, but only in a few countries of sufficient purity and in sufficient quantity to make its mining a profitable and continuous industry. The mineral has been fully treated and described in THE MINERAL INDUSTRY, Vols. I. and II.

Its principal uses in the arts are for making lead pencils, for stove polish, for refractory crucibles, for paint, and as a lubricant. The most generally known use is, of course, that for pencils, which are erroneously called lead pencils, probably because the name of black lead was given to the mineral when first mined in England. In crucibles, graphite supplies a place for certain uses which so far has been taken by no other material. The use of the mineral in making paint for covering and protecting metallic surfaces is very rapidly extending, as is also its employment as a lubricant. For bearings of certain kinds nothing better is known, and since its first introduction for this purpose its use has become widely extended.

The graphite industry in the United States is in the hands of a few companies, which do not market their output in a crude form, but entirely in manufactured shape. It will be seen from the table below that the product has been decreasing since 1891. No new deposits have been opened, and from the results shown in the table it does not appear that there has been any increase of development in the older workings. The falling off in imports last year shows a large decrease in the total consumption. In the absence of more exact data, however, we may conclude that part of this apparent decrease was due to the carrying over of stocks from the previous year, when the imports were unusually large.

From the figures given it appears that the average price of the graphite mined was 4.5c. per lb. in 1894, while that of the imported article was 1.9c. per lb. This last named value, while apparently lower than that of the graphite mined in this country, is not really so, as the imports include the impure and amorphous graphite, which is used chiefly for foundry facings.

The production of amorphous graphite from the Rhode Island workings in 1892 amounted to 1,770,000 lbs., valued at $3900; in 1893 to 2,898,500 lbs., valued at $7745; and in 1894 to 330,000 lbs., valued at $1252. This material is used chiefly for foundry facings.

GRAPHITE INDUSTRY IN THE UNITED STATES.

Year.	Production.		Imports.		Consumption.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1890	1,472,500	$77,500	25,595,500	$594,746	27,067,000	$672,246
1891	1,506,065	75,350	21,236,000	555,080	22,742,065	630,430
1892	1,298,363	64,920	23,354,000	667,775	24,652,363	732,695
1893	882,912	39,731	28,882,000	865,379	29,764,912	905,110
1894	770,846	34,689	11,640,000	225,720	12,410,846	260,409

The accompanying table gives the world's production for the years from 1890 to 1893, inclusive, with the United States and Canadian output for 1894:

THE WORLD'S PRODUCTION OF GRAPHITE (IN METRIC TONS).

Year.	Austria.	Canada.	Ceylon.	Germany.	Italy.	Japan.	United States. (a)	Total.
1890	23,728	159	32,225	4,355	1,735	4,573	272	67,047
1891	21,346	236	21,026	3,824	2,415	2,464	707	52,018
1892	20,978	151	21,300	4,036	1,645	601	634	49,345
1893	23,807	20	21,900	3,140	1,465	3	400	50,735
1894	.....	350	.....	3,133	.....	.....	349	.....

(a) Refined graphite.

While the mineral, as we have stated above, is widely distributed, the sources of commercial supply are comparatively few. The largest amount mined and sold is in Austria and Ceylon. In the former deposits are found in Bohemia, Moravia, Styria, Carinthia and Lower Austria. The largest mines are those at Schwarzbach and Przinitz in Southern Bohemia, which together furnish about three-quarters of the Austrian output. The Styrian mines furnish a quality of graphite which is highly esteemed for crucibles on account of its refractory nature.

The deposits of Moravia and Lower Austria, although extensive, are worked only to a small extent, on account of the numerous impurities with which the mineral is associated and the difficulty of separating it.

The Ceylon graphite is superior in quality to any other at present mined, and the island may therefore be considered as the most important producer in the world. In the quantity of its production it comes second to Austria. The industry in Ceylon is entirely in the hands of the natives, who mine and clean the mineral after somewhat primitive methods, but owing to the demand and the excellent quality the work is very profitable. There are a large number of small openings, chiefly in the western and northwestern portion of the island. The product is all exported to Europe and the United States. No attempt has ever been made to introduce improved methods, and it would probably be of little use to endeavor to compete with the native miners in this way, on account of the cheapness of labor.

The third producer of graphite in order is Germany, where a large quantity is obtained from the mines at Passau in Bavaria. These mines have been worked for several hundred years, but without exhaustion. As occurs in many similar cases, old methods have been retained here, and comparatively few improvements have been made. The production of the German mines is somewhat variable, but upon the whole is increasing slightly.

GYPSUM.

GYPSUM is a mineral widely distributed and found in many parts of the country. It is mined or quarried in New York, Virginia, Michigan, Ohio, Iowa, South Dakota, Kansas, Utah, Wyoming, Texas, California and the Indian Territory. Michigan, New York, Kansas, Iowa and Ohio are the more important producers in the order named.

In composition gypsum is a hydrous sulphate of lime. The color varies according to the purity, from white to gray, red, brown, blue and even black. In some cases it occurs in a transparent and crystallized form, under which it is known as selenite, sometimes in massive and fine-grained form as alabaster. Generally, it is a dull colored rock more or less mixed with clay and lime. It is usually found in beds, which in some cases are many hundred feet in thickness, and usually interstratified with clay and limestone. Its most usual occurrence is in the Silurian, Subcarboniferous and Cretaceous formations; it is also specially characteristic of the Triassic formation of the Rocky Mountain region.

The accompanying table shows the production of gypsum in the United States for the four years from 1891 to 1894 inclusive, by States; the statistics for the years prior to 1891 will be found in THE MINERAL INDUSTRY, Vols. I. and II.

PRODUCTION OF GYPSUM IN THE UNITED STATES.

(In tons of 2000 lbs.)

States.	1891.		1892.		1893.		1894.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
California	1,465	$14,410	1,140	$11,659	1,088	$10,179	1,630	$16,664
Iowa	31,385	58,095	21,392	39,575	21,447	55,538	20,000	47,000
Indian Territory	.....	.....	.....	.....	.....	.....	1,000	8,000
Kansas	40,217	161,322	41,106	195,197	58,165	268,935	57,675	292,068
Michigan	79,700	223,725	139,557	306,527	122,899	303,558	98,319	242,848
New York	30,135	58,571	32,394	61,100	68,983	113,379	68,723	122,254
Ohio	14,190	65,866	27,399	82,033	24,090	69,947	18,627	37,254
Texas	.....	.....	1,420	8,520	1,815	10,750	3,550	21,300
South Dakota	3,615	9,618	5,800	8,900	10,200	17,600	487	2,922
Utah	1,460	13,870	1,370	10,767	1,545	12,225	1,400	11,200
Virginia	5,959	22,574	6,991	28,207	18,499	57,904	15,856	45,915
Wyoming	1,100	6,400	1,400	7,100	1,500	7,600	250	2,500
Total short tons	209,226	$634,451	279,879	$759,585	330,231	$927,615	287,517	$849,925
Total metric tons	189,807	.....	252,903	.....	299,582	.....	260,834	.....

The decrease in the production last year, amounting to 42,714 tons, or about 13%, can be explained by the general depression in business and the partial stoppage of building and other operations in which gypsum is used. The production in 1894, however, was greater than that of 1892, the increase over that year being 7638 tons, showing that the industry has not suffered as severely as might have been expected. The decrease was somewhat unevenly distributed; in Michigan, which State is the largest producer, it amounted in 1894 to nearly 20%, and in Ohio to about 22%, while in New York, which is the largest producer next to Michigan, there was a falling off of less than 300 tons, and in Kansas, the third State in rank, of less than 500 tons. This difference probably arose from the fact that in New York and Kansas a larger proportion of the gypsum quarried is used locally and for agricultural purposes.

The chief industrial use of gypsum is in the form known as plaster of paris, in which it is employed for making molds, pressed ware, casts, etc., and for wall plaster. It is used also in the manufacture of artificial marble, in some forms of cement, and for many other purposes. To prepare the mineral for use in this shape the crude gypsum is calcined at a temperature not exceeding 260° C., when the water is driven off.

Another important use, which absorbs a large portion of the output, is as a fertilizer. In this form it is simply ground without calcining and is generally known as land-plaster. For certain crops and on certain soils it is considered very valuable.

A considerable portion of the gypsum taken out is sold in the crude form as it comes from the quarry. The price of crude gypsum ranges from $2 to $3 per ton, according to locality chiefly, the highest price, of course, being paid for products conveniently situated to a market. The price is increasing slightly, the average, as obtained from producers' returns, having been about $2.95 in 1894 against $2.81 in 1893. While the supply is large, it does not seem to grow more rapidly than the demand; it is found in so many places, however, that the output can be readily increased as a market is found for it.

Not many changes are to be reported for 1894. The Indian Territory made its appearance for the first time as a producer and 1000 tons were furnished from a deposit in that region. Texas, which first reported gypsum in 1892, is increasing its output to meet the local demand; the supply in that State is said to be unlimited, and the production is regulated chiefly by the demand and the cost of transportation. In California the output remained small owing to a comparatively light local demand.

IRON AND STEEL.

By Frederick Hobart.

The history of the iron trade in 1894 has been a most interesting one. The iron-makers of the United States throughout the year had to face the conditions of a light demand coupled with the lowest prices ever recorded in the history of the trade. The problem presented to the makers of pig iron was to run their furnaces with such regard to economy as to prevent actual loss, and to find a market for their product without forcing such increased competition as would still further reduce prices and present them the alternative of working at a loss or retiring from the field altogether and seeing their plants idle and unproductive.

Naturally, under such conditions, it was the larger, better equipped and better placed furnaces which were able to keep at work, while those which, on account of size, defects in machinery, or distance from supplies of fuel or ore, were not able to secure the highest degree of economy, had no choice but to go out of blast, leaving the field entirely to their better-equipped competitors. It was a simple case of the "survival of the fittest."

In the finished iron and steel trades the same conditions prevailed. Everywhere it was those works which were able to secure raw iron and fuel at the lowest cost, and which, from their size and the condition of their plants, were able also to enforce wholesale economies in management and operation which remained at work, since they alone were able to meet the market and to supply, for instance, steel billets at three-quarters of a cent per pound, and other articles at proportional prices.

Hard as such periods are, they are not altogether an unmixed evil to the iron trade, or indeed to other manufactures. In prosperous times there is always a certain tendency to extravagance in management. As long as a plant is running smoothly and making a profit, minor improvements—and great ones too, for that matter—will be neglected; and the possibilities of economy to be secured by close and intelligent attention to details are not realized until hard times enforce

the lesson. This is not peculiar to the iron trade; it is human nature, and is found in every branch of business.

It is not to be expected, however, in such a period as that under review, that any fundamental changes or improvements should be made. Economies in handling material, in the employment of labor, and in the details of work, may be looked for; but no radical changes involving the introduction of new and the abandonment of old machinery will be made, nor will any costly experiments be undertaken, however promising the result may seem.

The actual course of events in the iron and steel manufacture has been very much such as these general considerations would promise. To cover all that has been done during the year, however, would involve an amount of detail and an examination of individual plants which is not possible in a paper like the present, where the history of the trade can only be presented in general terms.

Iron Ore.—The production is necessarily dependent upon the general condition of the trade, and the degree of activity at the mines in a direct reflection of that at the furnaces. The table given herewith shows the production of iron ores in the United States for the five years ending with 1894; the statistics for the years preceding 1890 will be found in THE MINERAL INDUSTRY, Vols. I. and II.

IRON ORE PRODUCTION OF THE UNITED STATES.

Year.	Red Hematite.		Brown Hematite.		Magnetite.		Carbonate.		Total Production.		Imports.		Total Supply.
	Tons.	Per Cent.	Tons.	Per Cent.	Tons.	Per Cent.	Tons.	Per Cent	Tons.	Per Cent.	Tons.	Per Cent.	Tons.
1890..	10,527,650	60.9	2,559,938	14.8	2,570,838	14.9	377,617	2.2	16,036,043	92.8	1,246,830	7.2	17,282,873
1891..	9,327,398	60.2	2,757,564	17.7	2,317,108	15.0	189,108	1.2	14,591,178	94.1	912,864	5.9	15,504,042
1892..	11,646,619	68.1	2,485,101	14.5	1,971,965	11.5	192,981	1.2	16,296,666	95.3	806,585	4.8	17,103,251
1893..	8,272,637	68.3	1,849,272	15.3	1,330,886	11.0	134,834	1.1	11,587,629	95.7	526,951	4.3	12,114,580
1894.*a*	8,660,000	71.9	1,820,000	15.1	1,280,000	10.6	120,000	1.0	11,880,000	98.6	167,307	1.4	12,047,307

(*a*) Distribution estimated.

The production of iron ore in Canada in 1894 was 98,206 long tons, valued at $226,611; in 1893 it was 126,703 tons, valued at $298,018; in 1892 it was 92,186 tons, valued at $263,866; in 1891 it was 61,588 tons, valued at $142,005; and in 1890 it was 68,313 tons, valued at $155,380. At one time it was believed that a considerable amount of ore would be exported into the United States from the Canadian mines. This has not been the case, however, and nearly all the ores mined in that country have been consumed there, the shipments across the line being comparatively small.

In 1894 the production of the Juragua mines in Cuba was 164,416 tons, of which 150,440 tons were sent to the United States. In 1893 the output was 336,202 tons; in 1892 it was 335,521 tons; in 1891 it was 266,139 tons, and in 1890 it was 364,502 tons.

The marked reduction of nearly 5,000,000 tons from 1892 to 1893 shows the depression in the iron business in the latter year. In 1892 we were producing iron at the rate of over 9,000,000 tons yearly, and the total fell to a little under 7,000,000 tons in 1893; of course lessening by an equivalent amount the demand for iron ores. The reduction in the output of ores was really greater than that in consumption, for many large companies in the Lake Superior district and

elsewhere had at the close of the season of 1892 very large stock piles at the mines or at ore docks on Lake Superior from which part of the shipments of the following year might be made up. In 1894 there was no deduction of this kind to be made, and the mining as a rule was only equivalent to the demand.

Perhaps the most remarkable feature in the iron ore market was the extraordinary reduction in prices which was made necessary by the condition of the market. The Lake Superior iron ores, which may be taken as typical, sold in 1893 down to $3.75 per ton delivered at a Lake Erie port, and this was then the lowest price ever attained. At the opening of the season in the spring of 1894 the same ores sold at $2.75 per ton, and even lower prices are recorded during the season for the lower grades of these ores. At these prices it was claimed that many mines would have to shut down, and some of them did so; but others of the larger mines remained at work throughout the season, and while there was no notable increase in the area operated, there was, nevertheless, a good deal of exploration work done in the Mesabi region and the adjoining country.

In the following pages a very full acount will be found of the Lake Superior iron region, with a description of the different mines and of the various methods adopted in mining.

The low rates at which the Lake Superior ores were sold during 1894 had the effect of increasing their radius of consumption; that is, the distance from water transportation or from the ports on the lower lakes at which they could be sold and used. It is possible, therefore, that to some extent the narrow margin of profit at which the producers were obliged to work may be of advantage to them hereafter in securing customers from new markets, and enabling them to place their ores further east than they could otherwise have done.

Of the local iron ores in the various States but little new is to be said. Most of the iron mines in New York were closed down the greater part of 1894, although something was done at Crown Point and Ticonderoga. In New Jersey only a few of the large mines remained steadily at work and the same condition prevailed throughout eastern Pennsylvania.

In the South there were no important changes in iron mining although there continued to be some improvements in the methods of washing iron ores and preparing them for the furnaces. Something was done in the experiments in concentrating magnetic ore which have been in progress at Birmingham, but no commercial results have yet been attained; although it is said that a promising degree of success has attended the work so far.

The duty on iron ore, which the first draft of the new tariff bill introduced into Congress early in the season proposed to remove altogether, was reduced from 75c. to 40c. per ton. This reduction did not have the effect of inducing any considerable amounts of imports; although since the close of the year a considerable amount of Cuban and Spanish ores have been brought in for the furnaces on the Eastern seaboard which are beyond the range of the Lake ores and require just such an addition to their native ores as the Cuban mines can supply. We do not anticipate, however, that the importations will reach any very large figures.

Pig Iron.—The production of pig iron by States is shown in the following table:

PRODUCTION OF PIG IRON IN THE UNITED STATES BY STATES.

States.	1890.	1891.	1892.	1893.	1894.
Alabama	816,911	795,673	915,296	726,888	592,392
Colorado	21,061	18,116	32,441	45,555	73,669
Connecticut	20,135	21,811	17,107	12,478	7,416
Georgia	29,185	49,858	9,950	39,675	40,268
Indiana	14,641	7,729	7,700	5,567	.....
Illinois	701,107	669,202	949,450	405,261	604,795
Kentucky	47,860	44,844	56,548	47,501	33,854
Maine	1,072	.....	.....	.....	.....
Maryland	147,820	123,398	99,131	151,773	5,600
Massachusetts	4,938	8,990	7,946	7,853	156
Michigan	230,768	213,145	184,421	117,538	95,171
Minnesota	.....	1,226	14,071	10,373	.....
Missouri	89,777	29,229	57,020	32,360	6,522
New Jersey	158,740	92,490	87,975	74,305	63,273
New York	329,806	315,112	310,395	191,115	175,185
North Carolina	2,840	3,217	2,908	2,843	.....
Ohio	1,240,330	1,035,013	1,221,913	875,265	900,029
Oregon	10,987	9,295	7,628	4,739	1,000
Pennsylvania	4,415,329	3,952,387	4,193,805	3,643,022	3,370,152
Tennessee	267,625	291,738	300,081	207,915	212,773
Texas	9,700	18,662	8,613	6,257	4,671
Virginia	292,778	295,292	342,847	302,856	298,086
West Virginia	129,438	86,283	154,793	81,591	80,781
Wisconsin	219,854	197,160	174,961	131,772	91,595
Total	9,202,702	8,279,870	9,157,000	7,124,502	6,657,388

The total amount for the year as offi cially reported was 6,657,388 tons, showing a reduction of 465,114 tons from 1893; of 2,499,612 tons from 1892, and of 2,545,314 tons from 1890, which has thus far been the year of the greatest production in the United States. In point of time the reduction was entirely in the first part of the year. In June a slight increase was shown, which was later checked for awhile by the great strike in the coal mines and difficulties in obtaining fluel; but in August production began to gain with increasing rapidity, and at the close of the year it had very nearly reached the rate, estimated by the weekly capacity of the furnaces in blast, of 9,000,000 tons a year, at which it stood in the early part of 1893. Locally the reduction was not very unevenly distributed. The heaviest decrease in any State was in Maryland, where it was due to the stoppage of the great furnaces of the Maryland Steel Company at Canton. Two states—Ohio and Tennessee—showed a small increase, and in Colorado there was a large comparative gain on account of the blowing in of some of the furnaces of the Colorado Fuel and Iron Company at Pueblo.

Four States have dropped out of the list of producers entirely. Indiana made no pig iron in 1894, the furnace at Terre Haute having gone out. In Maine the Katahdin Iron Works, the only blast furnace in the State, has not been active since 1890. In North Carolina no furnaces were in operation, and the same can be said of Minnesota, although the last-named State is one of the more important producers of iron ore. In Massachusetts nearly all the charcoal furnaces in the western part of the State went out, reducing the production to a very low point, although some of those located on the same iron ore belt in Connecticut and eastern New York continued at work. On the Pacific Coast a single furnace in Oregon continues to be the only producer, and the work promised on the iron deposits of Washington has not yet been begun. Improving demand may change this condition of affairs.

The total production and approximate consumption of pig iron in the United

States for the five years under review, taking into account imports, exports and stocks, is shown in the following table:

PIG-IRON PRODUCTION IN THE UNITED STATES: IMPORTS, EXPORTS, STOCKS, AND TOTAL AND PER-CAPITA CONSUMPTION.

Year.	Production.				Imports.	Exports	Stocks.				Supply.	Consumption.		Estimated Population
	Anthracite.	Coke & Bituminous.	Charcoal.	Total.			Anthracite.	Coke & Bituminous.	Charcoal.	Total.		Total.	Per Capita, Lbs.	
1890	2,186,411	6,388,146	628,145	9,202,702	134,955	16,341	146,697	304,734	157,489	608,920	9,569,695	8,960,775	320.49	62.6
1891	1,866,108	5,836,798	576,964	8,279,870	67,179	14,945	124,369	258,678	213,374	596,421	8,941,024	8,341,603	292.76	63.9
1892	1,797,113	6,822,266	537,621	9,157,000	70,125	15,427	119,015	213,615	173,486	506,116	9,823,546	9,302,003	320.06	65.1
1893	1,347,529	5,390,184	386,789	7,124,502	54,394	24,570	166,359	288,528	207,181	662,068	7,685,012	6,998,374	236.8	66.2
1894	914,742	5,520,224	222,422	6,657,388	15,582	24,480	119,598	227,907	250,183	597,688	6,672,970	6,648,490	240.7	67.3

The imports and exports have not been sufficient in amount to have any considerable effect upon the trade. The stocks did not increase during 1894 in spite of the depression of business and were nearly 70,000 tons lower at the close of the year than at its beginning.

The production of spiegeleisen and ferromanganese in the United States was 133,180 tons in 1890, 127,766 tons in 1891, 179,131 tons in 1892, but in 1993 it fell to 81,118 tons, partly owing to the light demand in the steel trade and partly also on account of the large stocks on hand. In 1894 there was again an increase to 120,180 tons, which was very nearly the amount of production in 1891. Part of the ferromanganese is produced from the zinc ores of the Franklin mines in New Jersey, but most of it is made by the Carnegie Steel Company at its works near Pittsburg, and that company not only supplied itself with all that is needed in the steel manufacture but had a surplus for export.

It will be noted from the table that the decrease in iron production has been very unequally distributed among the different classes of furnaces. It has been customary for many years to group these according to the fuel employed, and on examining the table we find that at the worst time of depression the falling off in those furnaces which burn bituminous coal or coke—chiefly the latter—was comparatively small, and in 1894 this class of furnaces showed an actual increase of 130,000 tons over the preceding year. On the other hand the output of the anthracite furnaces, which are located chiefly in the Lehigh, Wyoming and Schuykill Valleys in eastern Pennsylvania, in the mountain region of New Jersey, on the upper Hudson and Lake Champlain, in New York, and along the seaboard, decreased heavily last year from the already diminished figures of 1893, showing for 1894 a total of only 914,742 tons, or less than half the quantity made in 1891. This confirms the remarks made in the first part of this article, and shows to what an extent the advantages of location near abundant supplies of cheap fuel and iron ores has thrown the business of production into the hands of western Pennsylvania in the North and Alabama in the South.

The coke furnaces of these last districts were able to keep running at a living profit when the anthracite stacks, with their higher cost for fuel and other disadvantages, were losing money. The probability is that this state of things will continue to a certain extent even through the better times and higher prices upon which we are now entering. The advantage of position is with the West-

ern and Southern furnaces, and the anthracite iron-makers of the East will be unable to compete with them except in special cases.

An instance of the prevailing tendency was found during the year when the large stack at Franklin Furnace in Sussex County, New Jersey, was dismantled and the machinery removed to Pennsylvania. This was one of the largest anthracite furnaces in the country, was equipped with the best machinery and located near abundant supplies of iron ore, but the owners judged it better economy to remove it than to attempt to keep it running at a distance from the supply of fuel.

The charcoal furnaces showed a heavy decrease last year, and their total production was only about one-third of the amount reported in 1890. In this case again the decrease in production is probably permanent. The output of charcoal iron has ceased to be a feature of any importance in the market. Last year it was only about 3% of the total, and the proportion is likely to grow less. Only a few special brands commanding a high price will in all probability continue to be made and the charcoal furnaces will practically disappear.

The fluctuations of the pig iron manufacture during the year can best be shown by the following table, which gives the number of furnaces in blast and the total weekly capacity in tons on the first day of each month during 1894:

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Furnace in blast..	137	128	134	144	124	91	109	136	169	172	186	188
Weekly capacity, tons	101,043	103,223	112,517	129,558	107,335	63,970	86,200	116,460	149,855	159,148	165,138	173,550

The following table shows the condition of the furnaces at the close of each year for five years, with the average output per furnace for each year:

CONDITION OF BLAST FURNACES IN THE UNITED STATES.

Year Ending Dec. 31.	Anthracite.			Bituminous and Coke.			Charcoal.			Total.		Grand Total.	Average Output Per Furnace, Tons of 2240 lbs.			
													By Fuel.			By No. in Blast.
	In Blast.	Out of Blast.	Total.	In Blast.	Out of Blast.	Total.	In Blast.	Out of Blast.	Total.	In Blast.	Out of Blast.		Anthracite.	Bituminous and Coke.	Charcoal.	
1890..	101	72	173	143	100	243	59	76	135	303	248	551	21,647	44,672	10,646	30,372
1891..	94	66	160	164	88	252	48	73	121	306	227	533	20,000	35,590	12,020	27,058
1892..	72	87	159	141	130	271	40	94	134	253	311	564	24,959	43,384	13,440	36,193
1893..	34	107	141	84	175	259	19	99	118	137	381	518	39,633	64,168	20,357	52,003
1894..	35	102	137	129	129	258	24	92	116	188	323	511	26,904	43,466	9,267	35,985

The tables which will be found in the following pages give the range of prices during 1894 and show to how low a point they were forced during the year. That in many directions manufacturers met this reduction in prices is an admitted fact, though not all of them are willing to confess at how low a cost pig iron was turned out. It was understood that early in 1894, at some of the Alabama furnaces, pig iron was being made at a cost not exceeding $6.50 per ton. This was disputed in a great many quarters, but we believe it to be the

fact that the actual cost at the furnaces was even less than that. Mr. E. C. Pechin, an expert who is thoroughly familar with the district, made a careful investigation about the time, the results of which were published in the *Engineering and Mining Journal* in July in a series of articles, has estimated that the actual cost of iron can be summarized as follows: Ore delivered at furnaces, $2.25; limestone, $0.16; coke, $2.31; total for materials, $4.62. To be added to this cost is $0.80 for labor and $0.94 for incidentals, making altogether $1.74 and bringing the total cost of the iron up to $6.36 per ton. This result, which is fully substantiated, is a most creditable one to the management of the furnaces in question, since it is but a very short time when it was considered impossible even in the Birmingham district to make pig iron for less than $8, and few anticipated that its cost could be reduced to $7, much less to a point below that figure.

We may add that there has been an improvement in the quality of the Southern iron as well as a reduction in cost, and this improvement is largely due to greater care exercised by the furnacemen in the choice of material and the mixture of ores and other details of the work. In fact, not only in the South, but all over the country, the assistance of the chemist is beginning to be much more highly appreciated by the iron-makers, and we believe that the time is not far distant when a competent chemist will be an indispensable member of the staff of every iron company, and constant analyses of the iron produced will be a regular feature.

Of the total output of pig iron in 1894, 3,808,567 gross tons, or 57.2% of the total, were classed as Bessemer pig; about two-thirds of this Bessemer pig was produced in Pennsylvania, the greater part of it in the Pittsburg district and the Shenango Valley, and most of it from Lake Superior ores. About one-sixth was produced in Ohio, chiefly in the Mahoning Valley.

The stocks of pig iron decreased somewhat during the year, the quantity reported at the close of 1894 being 597,688 tons, or 64,380 tons less than at the close of 1893. The furnaces were rather slow to go into blast, as a rule, until there was an actual demand for their product, and there was no accumulation of stocks during the year.

Finished Iron and Steel.—The production of steel—chiefly, of course, by the Bessemer process, but also including a small amount made by the Clapp-Griffith and the Robert-Bessemer processes—showed a small increase over that of 1893, the gain being entirely in the second half of the year. Of the total output of steel, a little over 65% was made in Pennsylvania, about 16% in Illinois and 10% in Ohio. There were no material changes during the year. One new Bessemer-steel plant using Robert-Bessemer converters was put in operation at East Chicago. It was the only new plant started up during the year; confidence in the future, however, was shown by the erection of two large plants which were not completed until after the close of the year. Both of these plants are located in Ohio, the first being that of the Ohio Steel Company at Youngstown and the other that of the Johnson Steel Company at Lorain. Both of them include the latest improvements and are expected to furnish a large output.

The production of open-hearth steel in the United States is steadily increasing. In 1894 it showed a gain of 47,046 tons over 1893 and even of 115,047 tons over

the prosperous year of 1892. According to the latest statistics there are 53 works now in the United States which make open-hearth steel.

The production of crucible steel in 1894 amounted to 51,702 long tons, a decrease of 11,911 tons from 1893 and of 33,007 tons from 1892. The output of crucible steel, independent of the reduction due to lighter demand, shows no tendency to increase, its place being taken to a certain extent by the other forms mentioned.

In addition to the production mentioned above there were 4081 tons of steel made in the United States by various patented and special processes, including blister and puddled steel.

Adding all the different kinds of steel together, we find that the total production of steel in 1894 amounted to 4,412,032 tons, showing an actual increase of 392,037 tons over 1893 and a decrease of 515,549 tons from 1892. The fact that the reduction from 1892 was much less in proportion than that in pig iron shows a continually increasing use of steel for various purposes, a tendency which has existed for some years past with apparently increasing force in each year. While we do not agree with those enthusiasts who predict that wrought iron will in a few years be unknown and puddling a lost art, there can be no doubt that the Bessemer and open-hearth steels are year by year forming a greater proportion of the material used in construction of all kinds, and that steel beams, plates and other forms are gradually driving the wrought-iron shapes out of the market. Whether they will eventually displace them as completely as the steel rail has the iron rail is doubtful, since there are many purposes for which Bessemer and similar steels are not so especially fitted as they are for the manufacture of rails.

It is certainly a notable fact that in a year of such depression the output of steel should reach an amount greater than that of any previous year except one. The figures for 1894 are exceeded only by those of 1892, and the production was greater by 10% than in 1891, although a comparison between the two years shows that the demand for steel rails last year was less by about 50% than in the earlier year.

The following table shows the production of steel for five years past:

STEEL PRODUCTION IN THE UNITED STATES.
(In tons of 2240 lbs.)

Kind.	1890.	1891.	1892.	1893.	1894.
Bessemer	3,688,871	3,247,417	4,168,435	3,215,686	3,571,313
Open-hearth	513,232	579,753	669,889	737,890	784,936
Crucible	71,175	72,586	84,709	63,613	51,702
Miscellaneous	3,793	4,484	4,548	2,806	4,081
Total	4,277,071	3,904,240	4,927,581	4,019,995	4,412,032

The total production of rolled iron and steel in various forms in 1894 was 4,787,807 tons, so that we may estimate that at least five-sixths of this finished output was probably of steel. It will be perhaps of interest, as showing the various changes in the iron and steel manufacture during the past few years, to compare the consumption of finished iron and steel for various purposes in 1894 with that in 1888, when the total output was about the same.

FORMS OF FINISHED IRON AND STEEL.

(In tons of 2240 lbs.)

Year.	Rails.	Bar, Shape, etc.	Wire Rods.	Plates & Sheets	Cut Nails.	Total.
1888.....	1,403,700	2,034,162	279,769	609,827	289,891	4,617,349
1894.....	1,021,772	2,301,471	673,402	682,900	108,262	4,787,807

The total output of finished iron and steel for five years has been: 1890, 6,022,875 tons; 1891, 5,390,963 tons; 1892, 6,165,814 tons; 1893, 4,975,685 tons; 1894, 4,787,607 tons.

We see from this table that during the period of seven years the proportion of the finished output formed by rails has decreased considerably, while that of shape iron and steel has largely increased, and there has also been an increase in plate and sheet. The output of cut nails included in the table was very much smaller in 1894 than in the earlier year, a fact which would appear somewhat strange were it not known that a very considerable part of the increase in wire rods was due to the introduction of the wire nails which have so largely taken the place of the older form.

It is not many years ago that the iron, and especially the steel, trade was dependent chiefly upon the railroad demand; while that demand is still an important element the proportion to the total is decreasing yearly. The great increase of the use of steel in buildings, bridges and other construction has reduced the rail manufacture to rather a subordinate rank, and this tendency is continually increasing with time.

The production and consumption of rails in the United States for the five years has been as follows:

PRODUCTION AND CONSUMPTION OF RAILS.

(In tons of 2240 lbs.)

Year.	Production.	Imports.	Exports.	Consumption.	Railroad Milage.	
					Total.	Increase.
1890.....	1,885,307	204	16,948	1,868,563	166,706	5,353
1891.....	1,307,176	253	11,239	1,296,190	170,795	4,089
1892.....	1,551,844	347	7,982	1,544,209	175,233	4,438
1893.....	1,136,458	2,888	19,876	1,119,470	177,862	2,629
1894.....	1,021,772	300	13,556	1,008,516	179,812	1,950

Of the total output of rails, 13,882 tons in 1890 were iron rails; in 1891 there were 8240 tons; in 1892, 10,437 tons; in 1893, 6090 tons, while in 1894 no iron rails are reported.

The railroad demand was light during the year, not only because the construction of new railroads was the least that had been known for a number of years, but also because in all, or nearly all, cases, the railroads postponed as far as possible all repairs and renewals, and their lessened business required little or no addition to their rolling stock.

To some extent the decreased purchases of the steam railroads were compensated for by a new element in the demand for material for the electric railroads which are being so rapidly introduced in all parts of the country. The present construction of the electric motor has made the cars used on these lines very

destructive to rails, and in addition to the demand for new roads there will be a constant one for repairs and renewals on existing lines of this class.

The basic or Thomas-Gilchrist process made no headway in the United States during 1894, nor were any new works of that class erected. In Germany and Belgium this process, however, continues to be very successful, and at the present time the larger part of the steel made in Germany is basic steel.

No improvements of great or special importance have been made in the manufacture of steel or in the metallurgy of iron during the year, although many minor ones have been made in the production and the economy of management, as already noted. The experiments with armor-plates made during the year have tended to confirm the opinion that nickel-steel is the best material yet made for that purpose, owing to its combination of hardness and tenacity.

The direction which special research has chiefly taken is that of the microscopic examination of the production of iron and steel in connection with the analysis of its composition. The results obtained by this course of research thus far have been interesting, but, perhaps, not altogether definite. In the working of iron and steel it seems probable that some opportunity will shortly be presented to settle the long disputed question of the relative efficiency of the steam-hammer and hydraulic press in forging, a point which has led to much argument, especially in France, where some interesting experiments have been made in the past, but without results as conclusive as might be desired. The two leading firms which supply armor-plate to the United States government have adopted the different systems: the Bethlehem Iron Company uses in forging the larger plates its great 125-ton steam-hammer, the largest in the world, while the Carnegie Company has recently put in a hydraulic press of the largest size for finishing these plates. So far but little difference has been perceptible between the plates furnished by these two companies.

Imports and Exports.—The following tables show the United States exports and imports of iron and steel in its various forms:

UNITED STATES IMPORTS OF IRON AND STEEL, TIN PLATE, ETC.

(In gross tons of 2240 lbs.)

Year.	Pig, Scrap (Iron and Steel), Spiegel, and Ferromanganese.		Bar Iron.		Iron, Band, Hoop, Cotton Ties, Scroll. Sheet, and Taggers' Iron.		Steel Ingots, Billets, Blooms, Slabs, Sheets, etc.		Tin and Terne Plates, and Taggers' Tin.		Rails.	
1889	180,388	$3,344,593	29,570	$1,097,132	*a*41,867	*a*$1,858,852	72,808	$1,989,837	323,274	$21,726,707	6,217	$163,339
1890	191,232	4,535,526	24,034	1,002,480	*a*30,218	*a*1,515,225	28,636	1,578,286	329,435	23,670,158	204	5,035
1891	67,179	1,432,455	18,099	770,858	*a*12,753	*a*781,557	34,685	1,673,214	327,868	25,900,305	253	8,405
1892	99,348	2,023,428	19,281	776,927	*a*71,756	*a*3,195,684	30,586	1,591,092	268,472	17,102,487	347	10,607
1893	60,667	1,321,899	14,896	603,985	*a*75,052	*a*3,276,537	26,868	1,293,834	253,154	15,559,423	2,888	57,584
1894	17,962	451,348	9,228	377,397	*a*52,254	*a*2,175,729	9,494	809,184	215,068	12,053,167	300	4,292

(*a*) Includes sheet steel and wire rods of iron or steel.

EXPORTS OF DOMESTIC IRON AND STEEL, ETC., FROM THE UNITED STATES.

(In tons of 2240 lbs.)

Year.	Pig Iron.		Bar Iron.		Band, Hoop, Scroll, and Iron Plates.		Steel Ingots, Bars, Rods, Steel Plates and Wire.		Rails. (*a*)		Total Value. (*b*)
1889	13,573	$227,048	779	$52,341	339	$29,540	8,738	$689,784	9,325	$309,825	$23,712,814
1890	16,341	266,107	1,068	97,817	519	48,168	10,776	886,244	16,948	577,916	27,000,134
1891	14,946	258,000	1,340	85,382	507	34,019	12,417	1,287,021	11,239	363,488	30,736,442
1892	15,427	282,290	963	60,463	290	21,662	15,403	1,036,123	7,982	256,325	27,900,862
1893	24,587	379,437	1,842	94,239	2,150	103,144	176,406	1,069,642	19,876	595,988	30,159,363
1894	24,480	309,222	3,196	130,374	2,326	98,057	28,054	1,409,346	13,556	356,186	29,943,729

(*a*) Of both iron and steel. (*b*) Includes all manufactures of iron and steel.

EXPORTS OF FOREIGN IRON AND STEEL, ETC., FROM THE UNITED STATES.
(In tons of 2240 lbs.)

Year.	Pig Iron.		Bar Iron.		Hoops, Bands, Cotton Ties, Strips, Sheets, and Steel Plates.		Sheet, Plate, Taggers' Iron or Steel.		Ingots, Blooms, Slabs, Steel Bars, etc.		Wire, Wire Rope, and Rods of Iron and Steel.		Tin Plates, Terne Plates, and Taggers' Tin.		Total Value. (c)
1889...	619	$7.285	43	$1,481	82	$3,022	10	$831	50	$2,182	54	$4,158	884	$58,440	$195,328
1890...	451	6,363	25	888	39	1,174	28	2,213	.....	.....	132	8,364	409	28,294	142,702
1891...	226	2,980	a34	1,151	b9	275	75	5.194	3	485	109	7,136	520	41,637	173,181
1892...	133	1,544	42	1,268	.....	.....	65	3,593	18	1,938	65	5,932	245	16,433	122,085
1893...	100	992	14	524	.....	.....	87	5.245	47	9,898	24	2,461	544	35,541	171,736
1894...	78	922	32	1,606	.....	.....	73	4,058	29	8,094	32	1,083	411	29,402	249,664

(a) Not including 19 tons railway bars of iron or steel, value $462. (b) Only hoop, band and scroll iron or steel. (c) Not including iron ore.

Iron and Steel Production of the World.—The table below shows the production of pig iron and steel in the principal countries of the world for five years past in metric tons. In nearly all of the leading iron producing countries, such as Belgium, France, Germany, the United Kingdom, the United States, Sweden and Spain, the figures are from the latest official returns. In a few cases where it has not been possible to obtain these in time we have estimated the output for 1894:

PRODUCTION OF PIG IRON AND STEEL IN THE PRINCIPAL COUNTRIES.
(In metric tons.)

Year.	Austria-Hungary.		Belgium.		Canada	France.		Germany.		Italy.		Russia.	
	Pig Iron.	Steel.	Pig Iron.	Steel.	Pig Iron.	Pig Iron	Steel.	Pig Iron	Steel.	Pig Iron.	Steel.	Pig Iron.	Steel.
1890..	965,382	499,600	787,836	245,566	19,751	1,962,196	581,998	4,658,451	2,161,821	14,346	107,676	927,585	378,424
1891..	921,846	a475,000	684,126	243,913	21,697	1,897,387	638,530	4,631,218	2,562,549	11,930	75,925	1,004,745	433,487
1892..	940,284	a480,000	753,268	260,037	38,514	2,057,300	682,000	4,937,461	a2,600,000	12,729	56,543	a919,614	371,199
1893..	982,707	a485,000	745,264	273,058	50,754	2,003,100	664,000	4,986,030	a2.600,000	8,038	71,380	a1,100,000	390,000
1894..	990,000	a490,000	810,940	396,914	45,327	2,077,647	663,264	5,559,322	a2,700,000	10,000	70,000	a1,140,000	a420,000

Year.	Spain.		Sweden.		United Kingdom.		United States.		All Other Countries.		Total.	
	Pig Iron.	Steel.	Pig Iron.	Steel.	Pig Iron	Steel.	Pig Iron	Steel.	Pig Iron.	Steel.	Pig Iron.	Steel.
1890..	170,782	75,255	456,103	169,287	8,033,052	3,637,381	9,353,020	4,341,226	301,959	a250,000	27,630,712	12,448,234
1891..	278,462	69,972	490,913	172,774	7,525,301	3,207,994	8,413,176	3,962,804	a350,000	a250,000	26,230,081	12,092,948
1892..	247,329	56,490	485,664	158,978	6,817,274	2,966,522	9,304,428	5,001,494	a350,000	a250,000	26,863,865	12,883,263
1893..	260,450	71,200	453,421	221,780	7,089,318	2,983,000	7,239,806	4,084,305	a350,000	a250,000	24,168,288	12,093,963
1894..	260,000	70,000	459,132	205,865	7,364,745	a3,050,000	6,757,248	4,482,592	a350.000	a250,000	25,821,361	12,798,635

(a) Estimated.

It will be seen that the production of pig iron in the world has not increased during this period, but is slightly less for 1894 than for 1890. This is due chiefly to the falling off on the part of the two leading iron producers, the United States and the United Kingdom; the other European countries, Germany, France and Belgium show an increase. The cause of this decrease in the United States we have already considered. In the United Kingdom the loss has been partly due to strikes and labor troubles; partly to the decrease in the demand from India and other colonies, and partly to a diversion of foreign trade

to Belgium and Germany. There has been also an actual decrease in the home consumption.

In 1894 considerably over half of the world's supply of pig iron was furnished by two countries, the United Kingdom making 28.5% and the United States 26.2% of the total. Germany, the third country in rank supplied 21.5%, and France, the fourth, 8.0%. The four countries named, therefore, made together 84.2% of all the pig iron turned out last year.

Upon the whole it may be said that the iron industry has not escaped the wave of depression which commenced with the Baring failure in 1891 and has been intensified by the depreciation of silver and other causes.

In Europe, as in the United States, the use of steel is rapidly extending, and the same general remarks will apply to the trade there as here, except that the depression in 1894 was less marked and the recovery began somewhat earlier. In Europe no less than in our own country, however, it has been a period of low prices and enforced economy in manufacture.

Further particulars of the iron and steel production will be found in the statistics given under the head of different countries.

In Great Britain the most notable point has been the rapid increase in the importations of foreign iron ores and the decrease in the working and consumption of native ores. A few years ago nearly all of this foreign supply was derived from the Spanish mines, but more recently the mines of Sweden and Norway have become an important source of supply, not only for the English but also for the German furnaces.

Spain.—The following table shows the Spanish production of iron and iron ores for five years past; the figures have been furnished us by Messrs. Barrington & Holt, of Cartagena:

SPANISH PRODUCTION OF IRON AND STEEL, AND EXPORTS OF IRON ORE.
(In metric tons.)

Year.	Production.				Exports, Iron Ore.
	Iron Ore.	Pig Iron.	Wrought Iron.	Steel.	
1890.....	5,788,743	179,433	63,933	63,011	4,696,944
1891.....	4,822,089	278,462	59,910	69,892	3,625,665
1892.....	5,405,142	247,329	122,295	56,490	4,773,827
1893.....	5,497,540	260,450	121,340	71,200	4,646,877
1894.....	5,500,000	260,000	120,000	70,000	4,988,222

The metallurgical industry of Spain, according to this table, shows very little change, but there have been notable fluctuations in the output of iron ore. Spanish ore is sold in England, Belgium and Germany, the quantity shipped to the last-named country being on the increase; and this has to some extent compensated for smaller sales made to Great Britain.

The Local Iron Markets in 1894.

The statement of the general conditions affecting the iron trade during the year will be more fully explained by the accounts given below of the course of business and prices at the leading markets.

New York.—This city is never a very active iron market. It is not an iron producing center like Pittsburg, and its factories are not of a class consuming as much raw iron and steel as those of Pittsburg. Although the business offices of many manufacturing and railroad companies are in the city the contracting for supplies is, in most cases, done elsewhere, and the local market is largely confined to the sales to foundries and shops in and near the city. These, however, are sufficient in number to create a large demand.

At the opening of 1894 Northern No. 1 foundry was quoted at $13.75@$14.25 in New York. By June this declined to $12.50@$13, and December quotations were $12.25@$12.75. Southern foundry No. 1 was quoted at $13@$13.75 in January; $12@$13 in June, and $15.50@$12 in December. With billets, there was a variation in prices, beginning at $19@$20 in January, declining to $18@$18.50, and advancing to $19@$19.50 in June, then falling to $18.50@$19 in September and further to $17.50@$18 in December. Wire rods declined from $28@$29 in January to $27@$27.50 in June, and $24.50@$25 in December. Steel rails were quoted $24 at mill and $24.80 at tidewater throughout the year, but this was reduced to $22 at mill and $22.75 at tidewater for 1895.

During the year the volume of local trade in New York was small in nearly all lines except in structural material. Pig iron sales footed up even less than in 1893, and the same may be said of other branches, with the possible exception of structural material, the sales of which were very irregular, though the total amount was somewhat more than in 1893.

Philadelphia.—The pig iron market presented very little of interest during the first nine months of the year. The unfavorable influences of the previous year continued without abatement. At the opening of the year the trade reports exhibited a hopefulness that subsequent events did not support. Quotations were about 50c. per ton above actual selling prices. Consumers all through the winter months exhibited an indifference to the course of the market and stubbornly refused to carry stocks beyond the requirements in hand.

By the opening of the spring trade the improvement that pig iron makers and brokers had promised themselves did not come, and those who had stocks in this market weakened it in their unsuccessful efforts to realize on it at then current rates. Both foundry and forge irons fared alike. All efforts to sell in a large way failed. The summer was looked forward to anxiously, but when it came prices were low and business dull. It was not until about October that more favorable conditions presented themselves. Consumption began to increase in this locality, but prices did not improve with the larger business. Mill irons showed a large consumptive demand, but buyers did not order for forward requirements.

At the close of the year the condition of the market was one of gradual improvement in fractional advances. All the finer makes of iron were sold up and stocks at some furnaces exhausted. Steel billets did not sell as manufac-

turers thought they would at the opening of the year. The requirements then in sight were large, and manufacturers anticipated an improvement in selling prices, but the prospects were delusive. Billets remained at a low level all winter, spring and summer. October quotations were $19 to $18, but increasing production and sharper competition were not long in driving prices down to $17.

Merchant iron opened at 1.40 and fell to 1.15 at the close, though card rates were higher. The rolling mills of eastern and middle Pennsylvania had a hard year working against obstacles, in which competition from mills west of the mountains was perhaps the greatest one. Quite a number of mills remained idle during the first half of the year. As autumn approached one after another resumed. During the last two months of the year all the better equipped and located mills had a fair volume of work, at prices ranging from 1.10 to 1.20 according to quality. Skelp iron was almost an exception to the rule, but productive capacity was just a little too much for the market, and prices kept close to cost of production all through the year. The last two months showed a slight improvement in small lots.

The sheet mills suffered less than the bar mills, but manufacturers found it impossible to obtain remunerative prices with 20% to 30% of the total capacity off so many months. The last three months of the year brought a steadier run of orders, and occasionally the prices named were remunerative.

The plate mills were unable to run with much regularity until rather late in the year. Heavy plates opened at 1.50 and closed at 2.25, but more favorable terms were made when large orders were placed. In December a better feeling was developed by the presentation of inquiries for large quantities of plate during the first half of 1895. Tank steel and shell varied but little. Structural material was in fair demand all the year and suffered less than almost any other product. Beams and channels opened at 1.65 and fell to 1.40. At the close of the year quite an encouraging volume of business was in sight.

Steel rails were neglected. Prices were held at $24 until the fall business opened, when $22 was agreed upon. The railmakers have had very little encouragement for several years, but there are signs that railroad building will begin to improve. The mill and furnace men have kept their properties in excellent repair despite the times, so that they are in condition to fill orders at lowest possible prices. The maintenance of the combination price depends upon the action of the Colorado Company and the new Youngstown mill.

Pittsburg.—The features of the iron and steel trades in Pittsburg during 1894 were exceedingly low prices and liberal transactions, particularly in soft steel. From January to July 1, prices showed $2 advance, and from the latter month to December a decline of $3.75 per ton, a net decline during the year of $1.75. There was a gradual decline in all leading products, large in some and small in others.

In raw material the year's transactions were the largest ever recorded. From January to July they amounted to 1,204,915 tons, and from July to December 1,027,984 tons, a total of 2,232,899 tons, exceeding 1893 by 593,673 tons. The sales of Bessemer iron ore reached 2,950,000 tons, prices ranging from $2.25 and $2.90 to $3.25 per ton on docks at Cleveland and Erie.

In Bessemer pig iron there was a marked reduction in the price. In May and June prices jumped from $10.50 to $13.75 for spot delivery, but the immediate wants of consumers being supplied, prices declined to $11.75 and $12.80 in July, and from then until the close of the year there was a further decline, closing at $10.25 and $10.30. In soft steel billets and slabs the sales were the largest ever recorded, largely because steel is superseding iron. From January to December there was a gradual decline in price, however. The year opened at $16.40@$17, but before February prices touched $15.50@$16, which held until May, when spot delivery advanced to $19.65. June opened at this figure, but closed at $18.50; July showed a variation from $19 to $17.25; August $18.25 to $17.25, and from this time until the close of the year there was a steady decline in price, which closed weak at $15.25 to $15.15. In gray forge iron the price has been quite uniform, opening $9.90 to $10.25 at the beginning of the year, and holding this until July, when a shade better was had until September. Since then prices have been somewhat weak, closing at $9.25@$9.40.

In foundry irons and sheet bars the decline in prices has been small compared with other iron and steel products. Sheet bars opened in January at $21.50; declined March 16 to $20.75; advanced to $22.50 in June and to $23 in July. These prices were fairly maintained until November, but they declined afterward, closing at $21. No. 1 foundry opened at $12 in January, and held this until March, when $11.50@$11.75 was held. An advance to $12 was made and held for some time, but in December the closing prices were $11.40 @$11.50. No. 2 foundry ranged from $11.25 down to 10.40. In ferromanganese the price for the first three months ranged from $50 to $53, but in June touched $54. August sales varied from $51.50 to $53.25, and from this time until the close of the year a a steady decline was noted, and closing prices were $48.40@$48.50. In muck bar, prices were uniform, ranging from $20.80 in January to $18.25 in December. Steel wire was opened at $23@23.50 in January; sold at $22.75@$25 in February; $24@$24.60 in March; $24.50@$25.75 in June, and $25.80 in July. During the following four months prices were on the down grade, touching $21.25@$21.50 in December.

PITTSBURG IRON TRADE IN 1894.

Month.	Tons.			Average Prices in 1894.								
	Bessemer.	Billets	Raw Material	Bessemer.	Billets	Gray Forge.	No. 1 F'dry.	No. 2 F'dry.	Short Bars.	Wire Rods.	Ferro-Mang.	Muck Bar.
January	25,500	37,550	115,770	$10.80	$31.16	$9.91	$12.00	$11.00	$21.52	$23.21	$51.60	$20.36
February	46,500	52,200	172,570	10.69	15.96	9.77	11.87	10.75	21.71	24.09	51.93	20.11
March	103,300	65 550	232,630	10.31	15.68	9.62	11.65	10.70	20.94	24.32	51.96	19.69
April	113,925	86,650	272,785	10.34	15.94	9.51	11.81	10.81	20.64	23.96	52.17	19.47
May	134,550	56,450	233,900	12.02	18.05	9.71	11.75	10.68	21.72	24.17	53.02	19.73
June	86,750	51,400	177,260	15.59	18.69	9.86	11.95	10.95	22.13	25.16	53.47	19.89
July	62,700	52,400	158,520	12.26	18.05	10.00	12.06	11.02	22.93	25.47	53.81	19.67
August	91,600	55,950	206 180	15.01	17.79	10.03	12.10	11.03	22.90	24.49	52.60	19.46
September	66,100	40,000	160,500	11.32	17.27	10.16	12.16	11.18	22.88	24.43	51.74	19.12
October	92,275	54,700	208,205	11.02	16.36	9.94	11.94	11.00	22.12	23.60	51.00	18.98
November	58,300	62,800	182,835	13.36	15.70	9.73	11.79	10.60	21.74	22.14	50.75	18.77
December 21st	38,321	33,585	111,744	10.24	15.34	9.47	11.50	10.50	21.36	21.49	49.58	18.44
First six months	510,525	349,800	1,204,915	$11.62	$16.77	$9.73	$11.83	$10.81	$21.44	$24.15	$52.36	$19.87
Second six months	409,296	299,435	1,027,984	12.20	16.75	9.88	11.92	10.88	22.32	23.60	51.58	19.07
Total	919,821	649,235	2,232,899	$11.91	$16.76	$9.80	$11.87	$10.84	$21.88	$23.87	$51.97	$19.47

Buffalo.—Buffalo is not an initial market, but a distributing point of importance, from which a large number of foundries and factories are supplied. The table below gives a statement of the average prices at Buffalo for each month of the more prominent irons entering that market. From the figures it will be seen that the course was constantly downward. During the months of July, August and September, that is, at the time of the coke strike and immediately after, there was a little firmness. The months of October, November and December demonstrated, however, that it was chiefly due to the scarcity caused by the strike. At the close of the year there were some indications of increased need, or at least more widely distributed demand.

PRICES OF PIG IRON PER TON AT BUFFALO FOR 1894.

	Jan.	Feb.	March.	April.	May.	June.
No. 1 Foundry Lake Superior coke....	$13.25	$12.75	$12.50	$12.00	$11.75	$11.50
No. 1 Jackson Co. Silvery soft coal....	16.75	16.75	15.75	15.50	15.00	15.50
Lake Superior charcoal.....	15.75	15.00	14.75	14.75	14.75	14.25
Standard Southern No. 1 soft coke....	12.75	12.50	12.50	12.25	11.00	11.00

	July.	Aug.	Sept.	Oct.	Nov.	Dec.
No. 1 Foundry Lake Superior coke....	$11.50	$11.25	$11.75	$11.75	$11.25	$11.25
No. 1 Jackson Co. Silvery soft coal....	15.75	15.75	15.75	15.75	15.75	15.75
Lake Superior charcoal.....	14.25	14.00	14.00	14.50	13.50	13.75
Standard Southern No. 1 soft coke....	11.25	11.75	11.75	11.75	11.50	11.25

Chicago.—Dullness and lack of confidence characterized the iron trade at the opening of 1894 and continued the greater part of the year. Reductions and readjustment of wages at furnace and rolling mill were rendered necessary by the fall in prices. Concessions on the part of employers and employés were required, and generally acquiesced in when properly presented to the latter, but in all directions mills were operated with smaller forces, and retrenchment was everywhere noticeable. From this condition of affairs the recovery was exceedingly slow; but locally extensions of elevated railroads took definite shape and the project of a new one, the Metropolitan, tapping the suburban towns to the southwest, gave a slight impetus to the demand for structural material. These improvements absorbed a heavy tonnage of iron and steel. Railroads, however, practiced a series of economies and postponed repairs as much as possible. Building operations, into which enter so much iron and steel, were slow, only some half dozen large office structures being erected during the course of the year. A series of strikes in April, May, June and July—miners, car-works, railroad employés and others—brought business in the West to a standstill. In June the scarcity of fuel caused the closing of many plants engaged in the manufacture of or consuming iron and steel. At the latter end of June and for part of July freight traffic on nearly all Western systems was suspended, resulting in the stoppage of foundries, factories, etc., on account of inability to obtain crude or finished material and fuel to carry on operations. Furnaces were also banked. Not until well after the middle of the year was there any particular change in the situation; by that time the tariff effect on manufactured products had been thoroughly discounted. In December there was a notable inquiry for

rolling stock, and a number of small contracts were placed by the leading railroads, but the demand from them for material of all kinds has been for minimum quantities.

In pig iron the main features were the light demand during 10 months, outside of the regular season's contracts; the steady decline in prices, and the gradual crowding out of Southern iron by Northern manufacturers. This latter was made possible by the lower price of ore, fuel and labor. The decline in price, which was steady throughout the year, was between $4 and $4.50 on Northern iron and about $1.50 to $2 on Southern. The year also witnessed the dismantling of several charcoal furnaces on account of the further substitution of coke-made iron for Lake Superior charcoal iron. At the commencement of the year there was not a furnace using coke fuel in blast in this district, and for several months there were only two doing anything, one of these running on Bessemer. Southern iron lost by the steady decline in price of the Northern product, and while silveries, softs and silicons will continue to command a certain amount of attention from buyers, the ordinary foundry grades are now practically barred from the Chicago market, except in a small way.

Billets and steel rods also suffered in price—billets dropping from $19.25 to $17, and rods from $26.50 to $23.50. The year opened with these industries at a complete standstill, but they began to pick up in February, and with several short periods of idleness were active nearly all the year. The break in the barb-wire pool in the fall stimulated demand for rods.

Outside of the elevated railroads and a few office buildings, the demand for structural iron was fair only during 1894. No specially large engineering enterprises were projected, but during the second half of the year there was an increased demand for bridge plates and other specialties in that branch. Prices receded $1.50 to $2 per ton.

Early in the year a fair tonnage of plates was contracted for, but generally the boiler trade was quiet, with a marked change in the specifications—cheaper grades being particularized. Quotations receded $3 or $4 per ton.

The principal consumers of merchant steel are the agricultural implement, carriage and wagon makers, and the tonnage taken by them the past year was in excess of that of 1893, but still behind the amount consumed in 1892. Prices show a falling off between $2 and $3 per ton.

In bar steel and iron the light demand from railroads and the enforced economic operation of works have been felt severely by rolling mills in this vicinity, which have run from one-third to one-half capacity. In other manufacturing lines the demand has also been light, excepting the agricultural works. The shut-down during the summer was continued by some well into the fall months, and the competition for even small orders was such as to force values very close to cost. Prices dropped $1.50 to $2 per ton, the fluctuations being very slight, though at the close prices were a trifle higher than they were in October.

The market for black and galvanized sheets was well supported, since there has been a remarkable growth of the iron and steel roofing industry during the past few years. The increase in demand showed little diminution during 1894, and while building operations were more or less restricted most of the mills making these

sheets were well employed during the greater part of the year. About $1.50 to $2 per ton will cover the depreciation in price.

The demand for rails was small, as in other markets. The Union and Joliet mills did not roll any rails, and the South Chicago works ran only part of the time. A new competition for Western business is the Colorado Fuel and Iron Company, which absorbed a certain tonnage which would otherwise have been placed with the Chicago mills.

Prices of old material steadily declined the whole year. The inroads made by steel billets, with steadily increasing consumption by rolling mills, were severely felt by the scrap market. Demand was light and the trade much depressed. Old iron rails declined from $13 to $10.25@$10.50.

Prices of Iron and Steel.

The following table shows the prices of iron and steel in Pittsburg for the five years ending with 1894; these may be taken as exemplifying the range of prices in the United States. The second table shows, for purposes of comparison, the prices of iron in Germany for the same period.

CASH PRICE OF IRON AND STEEL IN PITTSBURG LAST WEEK OF DECEMBER.

Year.	Pig Iron.													
	Bessemer.	Coke, Foundry.							Charcoal Iron.				Ferro-Manganese, 80%.	Spiegel, 20%.
		No. 1.	No. 2.	No. 3.	Gray Forge	Mottled.	White.	Silvery	No. 1.	No. 2.	Cold Blast.	Warm Blast.		
1890	$16.50	$17.25	$16.25	$14.75	$14.25	$14.25	$14.25	$16.50	$24.00	$22.50	$26.00	$24.50	$65.50	$30.00
1891	15.75	16.00	15.25	13.65	13.25	13.25	13.25	17.00	22.50	20.50	26.50	19.50	63.00	27.00
1892	13.75	14.25	13.25	12.60	12.50	12.00	12.00	16.00	20.00	19.00	25.00	19.00	61.00	28.50
1893	11.00	12.25	11.25	10.00	10.00	10.25	10.60	15.50	18.50	18.00	25.00	18.00	52.50	23.75
1894	10.25	11.50	10.50	9.50	9.25	9.00	9.00	13.60	17.00	16.25	23.50	16.25	48.00	18.50

Year.	Steel.							Wrought Iron.						Coke at Furnace.
	Billets.	Rail Ends.	Bloom Ends.	New Rails.	Old Rails.	Steel Nails.	Wire Nails.	Muck Bar.	Old Rails.	No. 1 Scrap.	No. 2 Scrap.	Bar Iron.	Iron Nails.	
1890	$26.00	$17.75	$17.50	$29.00	$18.50	$1.90	$2.10	$29.50	$26.00	$22.00	$18.00	$1.85	$1.90	$2.15
1891	24.50	17.25	17.25	30.00	17.50	1.60	1.70	26.00	23.25	24.00	17.50	1.65	1.60	1.90
1892	22.50	15.50	16.00	30.00	14.50	1.55	1.55	24.50	20.50	20.50	15.00	1.60	1.55	1.90
1893	16.75	11.50	11.50	24.00	10.50	1.10	1.20	21.00	14.50	16.25	15.00	1.45	1.10	1.15
1894	15.25	10.40	10.40	22.00	10.00	1.00	1.00	18.40	12.50	10.00	6.00	1.15	1.00	1.00

AVERAGE YEARLY PRICE OF IRON AT THE PRINCIPAL MARKETS IN GERMANY. (*a*)
(Price in marks per 1000 kilos; 1 mark = 23.8 cents.

Year.	German Pig.							English Pig.				Lübeck.
	Breslau, at Works.		Dortmund, at Works, from Ruhr District.			Düsseldorf, at Works.		Berlin, Free on Shore.		Hamburg, Duty Paid, from Store.		
	Puddle.	Foundry.	Bessemer.	Westphalian Puddle.	Thomas Pig.	Best Puddle	Best Foundry.	Scotch, No. 1.	Middlesbrough, No. 3.	Scotch, No. 1.	Middlesbrough, No. 1.	Rod Iron, A1 Stockholm.
1890....	66.60	74.44	79.83	70.00	60.96	77.50	83.63	93.02	71.79	89.14	70.82	227.67
1891....	48.21	54.79	62.08	52.08	49.50	52.83	71.17	81.99	61.52	80.53	62.41	208.54
1892....	48.88	52.58	57.83	50.54	49.33	51.38	65.50	73.46	58.69	70.31	60.04	206.46
1893....	50.21	52.46	52.00	46.71	45.54	46.25	62.00	74.83	54.98	68 52	55.92	206.67
1894....	49.33	50.33	52.00	45.58	45.17	45.25	62.75	85.81	55.70	72.28	56.65	204.38

(*a*) From *Vierteljahrshefte zur Statistik des Deutschen Reichs*, Berlin, Part I.

Lake Superior Iron Ore.

By J. Parke Channing.

The year 1894 was one of neither pleasure nor profit to the producer of Lake Superior iron ore. There are a few mines with low or no royalty, favorable position as regards rail and lake transportation, and ore of a high grade or easily mined, that were able to make a little money. On the other hand many mines have been permanently closed down and the investment wiped out, while some prominent companies lost in mining operations in 1893 and 1894 over $300,000 each, without counting the exhaustion of ore reserves.

During the last three years the values of iron company's stocks have decreased at least 75%, as the following figures indicate: Pittsburg & Lake Angeline Iron Company, from $175 to $65; Cleveland-Cliffs Iron Company, from $100 to $25; Minnesota Iron Company, from $90 to $40; Lake Superior Iron Company, from $65 to $20; Michigamme Company, from $10 to nothing.

Notwithstanding this loss, the old range mines have tried as much as possible to keep going, so that their men would not be without income, though wages have gone down from an average of $2 per day in 1892 to a maximum average of $1.35 in 1894. These figures give the average of the pay roll and include all the men, from the highest-priced contract miner to the cheapest surface laborer.

Contract miners' wages in 1892 would run from $2.40 to $3 per day, depending on the skill of the men. In October, 1894, on the Marquette range, they would run from $1.40 up to $1.90 per day; on the Menominee range from $1.05 to $1.50; on the Gogebic range from $1.15 to $1.75, the Norrie contract wages averaging $1.45 to $1.50. On the Vermilion range, in the early part of the year, the average wage—miners, trammers, timbermen and surface hands included—was very close to $1. In the latter part of the season this advanced to $1.50. On the Mesabi range wages were higher. In October, 1894, laborers in the open-pit mines were getting $1.50 per day, having been advanced from $1.25, the rate in the earlier part of the season. Skilled men, such as steam-shovel engineers, cranemen, switch-engine drivers and firemen, were being paid old-time wages.

Supplies of all kinds were lower, and yet it is doubtful whether the reduction would average over 20% from the prices of 1892. Mine timber was lower, on account of lower wages to the choppers and framers. Powder was lower, 30% dynamite on the older ranges selling for 8c. per lb. Coal was lower, not only at Lake Erie ports, but also at Lake Superior ports, because of low lake freights. On the Menominee range, good soft wood was delivered at boiler-houses for $1.35 per cord, and at this price was much cheaper than coal. Rails, iron, steel, rope, candles, fuse, caps, oil, waste, etc., were lower, and yet to the older ranges the saving per ton of ore could not be very much. In the underground mines on the older ranges the general average of the cost of supplies is 25c. a ton, taxes run from 2c. to 15c. a ton, and the balance of the cost comes from the pay roll or is the labor cost.

The total cost of mining ore in 1894 on the older ranges varied from 60c. to $1.20 per ton for soft ore, running up to $1.35 and $1.50 for hard ore. While

these figures are low, they were attained first by the reduction in wages to a point below the standard of comfort for a country with six months winter, and secondly, by the stoppage of all dead work or opening. This latter expedient will soon have to be abandoned, as the reserves of the mines become exhausted. On the Gogebic range there has been but little sinking done in the last two years. What it costs to mine Mesabi ore, and what it will cost to mine it, are rather difficult questions to answer, unless one has the individual problem in each case to treat. There has not been any 15c. ore mined this year. Where such a figure is quoted we may look for some equipment account, or stripping account, which would add an important amount to that figure. It is more nearly correct to put the cost of mining at from 25c. to 60c. per ton on the cars.

The older ranges have felt the competition of the Mesabi, but they have been more frightened than injured, and moreover, in 1894, ore was sold too cheaply.

In the early days it was reported that all the Mesabi ore was low in iron and high in phosphorus. This idea unquestionably came from pits that were simply sunk through the drift and bottomed on ore. Later on it was stated that this low-grade ore was only on top, and that the sinking of pits and drill-holes showed that the good ore was underneath. The results of the work of 1894 have shown that the ore does not run regularly, particularly as regards phosphorus, and that the selection of different grades of ore from the same body will be as difficult as on the older ranges. This will be particularly so in case the ore is mined with a steam shovel.

In putting ore upon the market it is usual to figure the cost of the ore laid down on dock at a Lake Erie port, as most ore is sold in that way. In figuring this cost per ton, six items are to be considered : 1, mining; 2, royalty; 3, railroad freight; 4, lake freight; 5, commission for selling; 6, general expense and insurance.

1. *Mining* is the cost of exploration, development, equipment and exploitation of the ore at the mine. It may be summed up in saying it is the money sent the superintendent to pay for labor, supplies and taxes, and should cover all expense necessary to put the ore into the cars of the railroad company. The following will show the cost of mining ore for the year 1894 on the various ranges per gross ton : Marquette, 75c. to $1.50; Menominee, 50c. to $1; Gogebic, 60c. to 90c.; Vermilion, 60c. to $1.20; Mesabi, 25c. to 60c.

2. *Royalty.*—When the ore has been loaded upon the cars it is turned over to the railroad company, and its weights are those used in settlement of the royalty, which is the payment made to the owner of the land upon which the mine is located. It varies from 20c. to 50c. per ton of ore shipped, although there are some as low as 5c. on the Mesabi range. Royalties have been coming steadily down in the last few years, and with justice. The system of large guaranteed minimum royalties on some of the Mesabi mines has done that range much harm, but during the last year many intermediate lease-holders, between the fee-owners and the operating companies, have been quietly dropped out. It should not be forgotten that every ton of ore taken from a mine reduces the property's ultimate value. Strictly speaking, when we say that a mine has no royalty to pay, we mean that at some time or other it paid its royalty in a lump,

say when it acquired title to the land. If this be so, a sinking fund should be established to extinguish this investment.

3. *Railroad Freight.*—The railroad companies provide cars, transport the ore to the lake ports and dump it into the docks. They load the vessels from the docks, but the vessel is obliged to trim its own cargo after it has been run into the hold from the dock chutes. Rail rates of 1893 for the Marquette, Menominee and Gogebic ranges were cut for 1894 on a basis of 20% from the Ishpeming-Escanaba rate. On the Mesabi and Vermilion ranges rates have remained the same. There is talk of legislative action to compel a reduction. Rates for 1894 were as follows:

Ely to Two Harbors	$1.00	Gogebic Range to Ashland	$0.52
Tower to Two Harbors	.80	Menominee Range to Escanaba	.52
Mesabi Range to Two Harbors	.80	Marquette Range to Escanaba	.52
Mesabi Range to Duluth	.80	Marquette Range to Marquette	.32

4. *Lake Freights* for the year were so low that vessel-men claim they lost money. They secured a small reduction in trimming charges and also in the cost of unloading at Lake Erie ports. Both these charges have to be paid by the vessel. Charters averaged as follows to Lake Erie ports: From Two Harbors, Duluth or Ashland, 80c. per ton; from Marquette, 70c. per ton; from Escanaba, 50c. per ton. It will be observed that the differential in the water rate between Marquette and Escanaba is 20c. in favor of Escanaba. To offset this, as far as the Marquette range is considered, the rail rate to Marquette is 20c. less than to Escanaba. During the season the difference between the water rates to Marquette and Escanaba might be more or less than 20c., and this fluctuation would tend to send ore alternately to Marquette and Escanaba from the same mine. Deepening of the lake channels in the future will have a tendency to lower the cost of carrying ore.

5. *Commissions* paid to the ore agents are still 10c. per ton. It certainly seems that this is too high, since it is the same as when ore was selling for two or three times what it now brings. With lower rail and lake freights and lower mining costs the ore agents have less money tied up in advances, and with the same capital should be able to handle more ore. Their business is safer than it was, for no mine can ask for money to-day unless it has the ore in the cars or in stock pile.

6. *General Expense* and insurance cover the cost of marine insurance on the ore and such items as analyses, sampling, interest and discount on bills, and expenses of Cleveland or home office of the company. These are generally calculated at about 5c. per ton, but may run down to 2c. or thereabouts.

The sum of items 3, 4, 5 and 6 for the several ranges is as follows: Marquette and Menominee, $1.17; Gogebic, $1.47; and Mesabi, $1.75. If we assume that ore brings $2.75 per ton in Cleveland, this leaves for cost of mining, royalty and profit the following: Marquette and Menominee, $1.58; Gogebic, $1.28; and Mesabi, $1. This indicates that freights are such as to give the Marquette and Menominee ranges an advantage of 58c., and the Gogebic an advantage of 28c., over the Mesabi.

The following table will indicate the prices paid for the leading ores in Cleveland for the year 1894. The table is not complete, but shows about the run of the different classes of ore:

Grade.	Range.	Iron.	Phosphorus.	Price.
Minnesota hard	Vermilion	67.0%	0.050%	$3.35
Chandler	Vermilion	64.0	0.040	2.95
Norrie	Gogebic	63.0	0.045	2.75
Franklin	Mesabi	64.5	0.035	2.60
Mountain Iron No. 1	Mesabi	62.5	0.040	2.40
Canton	Mesabi	62.0	0.045	2.25
Mountain Iron, Tubal	Mesabi	62.0	0.050	2.15
Cleveland Lake	Marquette	61.0	0.100	2.10
Dunn	Menominee	62.0	0.150	2.05
Davidson	Menominee	58.0	0.250	1.70

The accompanying table shows the shipments from the mines for 1894; it was compiled by Mr. George A. Newett of Ishpeming, Mich., editor of *Iron Ore*, his figures being obtained from the mining companies, and showing shipments from the docks, but not including ore shipped by the mines and left on docks at the upper lake ports. Cleveland shipments and Iron Cliffs shipments comprise the total of the Cleveland-Cliffs Company. Norrie and East Norrie are given separately, probably because they have different fee-owners; these two mines are operated by the Metropolitan Iron and Land Company on the same ore body, and their total output, 620,000 tons, leads the list in amount. The Colby and the Tilden are working on the same ore body under the same management, with different fee-owners. Mountain Iron and Rathbun should be considered together, for the same reason.

IRON ORE SHIPMENTS FROM THE LAKE SUPERIOR RANGES FOR THE SEASON OF 1894.

Range.	Tons.	Range.	Tons.	Range.	Tons.	Range.	Tons.
Marquette—		Menominee—		Gogebic—		Mesabi—	
Ames	5,196	Aragon	138,227	Anvil	13,297	Auburn	107,323
Blue Iron	32,172	Chapin	235,896	Aurora	203,152	Biwabik	90,023
Cambria	47,226	Commonwealth	174,921	Ashland	83,020	Canton	213,853
Champion	42,788	Columbia	11,537	Brotherton	47,150	Commodore	7,213
Cleveland	210,074	Dunn	24,588	Cary	17,238	Franklin	223,400
Davis	12,073	Florence	2,726	Colby	13,589	Hale	24,167
Dexter	21,740	Lamont	2,343	Comet	11,900	Missabe Mountain	505,955
Iron Cliffs	187,392	Loretto	55,984	Eureka	18,330	Minnewas	2,162
Jackson	32,299	Mich. Ex. Co.	77	East Norrie	194,769	Mountain Iron	556,777
Lake Angeline	355,453	Millie	13,064	Iron Belt	45,109	Norman	39,008
Lake Superior	343,783	Penn Mines	175,274	Montreal	46,037	Rathbun	16,663
Lilly	80,380	Pewabic	304,009	Newport	150,392	Vega	5,628
Marquette	56,456	Shafer	677	Norrie	426,855		
Negaunee	132,493			Odanah	2,437	Total	1,792,172
New York	21,487	Total	1,139,273	Pabst	206,076		
Platt	41,246			Palms	37,911		
Queen	220,300			Superior	30,598	Vermilion—	
Republic	105,719			Sunday Lake	34,324	Chandler	558,051
Starwest	5,550			Tilden	228,106	Minnesota	390,463
Volunteer	26,946						
Winthrop-Mitchell	77,910			Total	1,810,290	Total	948,514
Total	2,058,683						

RECAPITULATION.

Port.	Marquette Range.	Menominee Range.	Gogebic Range.	Vermilion Range.	Mesabi Range	Total.
Marquette	1,424,409					1,424,409
Escanaba	580,154	1,029,100	47,986			1,657,240
Gladstone		79,109				79,109
Ashland			1,731,703			1,731,703
Two Harbors				948,514	424,830	1,373,344
Duluth					1,367,286	1,367,286
Total lake	2,004,563	1,108,209	1,779,689	948,514	1,792,116	7,633,091
All rail	54,120	31,064	30,601		56	115,841
Total	2,058,683	1,139,273	1,810,290	948,514	1,792,172	7,748,932

SHIPMENTS OF LAKE SUPERIOR IRON ORE BY PORTS FOR FIVE YEARS.

Year.	Marquette.	Escanaba.	Gladstone.	Ashland.	Two Harbors	Duluth.	Total Lake.	Rail.	Total.
1890..	1,307,395	3,714,662	91,091	2,123,556	826,063	.....	8,062,767	940,634	9,003,401
1891..	1,056,027	3,058,590	177,866	1,261,658	890,299	.....	6,444,440	651,541	7,095,981
1892..	1,026,338	4,010,085	115,886	2,223,683	1,165,076	4,245	8,545,313	528,930	9,074,243
1893..	1,086,934	2,048,981	203,585	1,117,524	903,329	520,565	5,880,918	178,037	6,058,955
1894..	1,424,409	1,657,240	79,109	1,731,703	1,373,344	1,367,286	7,633,091	115,841	7,748,932

Superior shipments are included in Duluth.

SHIPMENTS OF LAKE SUPERIOR IRON ORE BY RANGES FOR FIVE YEARS, WITH TOTAL FROM OPENING OF THE RANGES.

Year.	Marquette.	Menominee	Gogebic.	Vermilion.	Mesabi.	Total.
1890.....	2,993,664	2,282,237	2,847,786	880,014	.....	9,003,701
1891.....	2,511,395	1,843 326	1,848,721	891,539	.....	7,094,981
1892.....	2,666,856	2,261,499	2,973,993	1,167,650	4,245	9,074.243
1893.....	1,829,053	1,466,197	1,329,464	820,621	613,620	6,058,955
1894.....	2,058,683	1,139,273	1,810,290	948,514	1,792,172	7,748,932
Total from opening of ranges....	41,808,293	19,384,820	16,386.976	7,054,308	2,410,037	83,044,434

The total shipments in 1894 showed a decrease of 1,325,311 tons, or 14.6% from 1892, the year of largest production; but they exceeded those of 1893 by 1,689,977 tons, or 27.9%. Of the shipments for 1894 the Marquette range furnished 26.6%, the Menominee 14.7%, the Gogebic 23.4%, the Vermilion 12.2%, and the Mesabi 23.1% of the total.

Following this general statement the ranges are taken in order, discussing such points as are of interest, both from a commercial and technical point of view.

GOGEBIC RANGE.

Beginning at the east end of the range, the Comet, Sunday Lake and Brotherton mines are shut down and filled with water. The Comet ore bodies were small and it is doubtful if the mine will be wrought for some time to come. The Sunday Lake and the Brotherton have a good grade of Bessemer ore, but the ore bodies are not large, require much rock-work to reach them, and the pumping charges, as the mines are now equipped, are rather heavy. The Brotherton can produce 100,000 tons per year. It is reported that the Sunday Lake has some exceptionally low phosphorus ore in the mine. The Eureka, near Black River, is working in a small way. The Anvil has been shut down some time, but still has a considerable lot of ore opened up and ready to mine. The Palms, operated by the Lake Superior Consolidated Mines, is closed, and it is reported that the lease has been given up, as too high a royalty is demanded by the fee-owners.

At the Colby Mine Section Sixteen, which was the main mine in the days of Mather, Morse & Co., work has been given up and all buildings and machinery moved to Section Fifteen, or the Tilden, as it is called. Here mining has been going on through Shafts Nos. 8 and 9. Shaft No. 8 was the old "Fifteen" inclined shaft, which has been sunk down until it encountered the main lens of ore. No. 9 is one of the hanging-wall, vertical shafts.

The Federal (Tontine), Lowell (Ironton) and Ruby (Puritan) are filled with water. At the Newport, which includes the old Bonnie and Iron King, all

mining is being done on the south vein, beginning at the crest of the Iron King hill and running down to the Pabst line. On the Bonnie, careful, systematic exploring is in progress, which may result in discoveries in the low ground near the First National.

The Pabst is being wrought by the Norrie people and most of the ore comes from the south vein. The Aurora has been working all summer and has found some new ore on the hanging side. Work on the North Aurora vertical shaft has been suspended.

The Norrie mine was shut down nearly all the winter of 1893–94, and started up in the spring in order to give the operatives, who had been subsisting on charity, something to do. Ore was sold at the unprecedented low price of $2.75 per ton, and it required the closest economy to make ends meet. That the action of the mining company in selling ore at cost was not appreciated by the men may be seen by the strike that occurred at Ironwood during the summer. But little sinking has been done in the past two years, the foot-wall as well as the two vertical hanging-wall shafts having been stopped.

The Ashland Mine has been shut down for some time and the water has been gradually rising till it now runs over into the Norrie. During last summer what ore was mined came from the new north vein body, which was discovered the year before. This ore was hoisted through two small exploring shafts and the season's work is reported to have been done more cheaply than that of any other mine on the Gogebic. Last November the management of the mine passed into the hands of the Lake Superior Consolidated Mines. The prospects for the Ashland are not very bright. No. 3 shaft was sunk to a depth of 1300 ft. underlay and struck nothing of value, nor was this surprising in view of the eastern pitch of the lenses and the barrenness of the ground west of No. 3.

The Germania's plant was bought in by the fee-owners last autumn, and that mine, as well as all the mines west of the Montreal river, as far as the Montreal mine, are shut down.

The first mine in Wisconsin that is being wrought is the Montreal, which is now consolidated with and operates the Section Thirty-three mine. There are three new levels opened up on what was the original Pence lens. This lens runs across the old Montreal forty and is now on the Section Thirty-three forty. The mine has been equipped with a new 25-drill air-compressor, and in 1895 it can put out 200,000 tons of high grade ore.

Nothing is being done at the Father Hennepin or Pence. The Atlantic is being wrought, and also the Iron Belt. The Iron Belt is doing some work at the west end of its property on the quartzite or south vein. The main ore body is a north-vein deposit, opened up by three shafts.

With one or two exceptions, the amount of Bessemer ore in sight in the Gogebic mines is not very large; judging from all the available data, it is doubtful whether there is much over 15,000,000 tons of Bessemer ore left on the range. There certainly is not that much developed.

The system of mining employed has not varied much since the range started. Square-set rooms with pillars between are the general rule. The rooms are then caved and the pillars taken out either by drawing from the bottom or by slicing from the top and hanging sides with light timbers, allowing the hanging or

capping to settle a slice at a time. At the Colby the hanging and capping have proved so solid an envelope to the ore lens that timber, except in the main drifts, has been abandoned. The ore is practically milled down in a huge underground quarry to the various loading places on the main levels. The management claims that little ore is lost and that the grade is kept up.

MENOMINEE RANGE.

At the east end of this range there are two comparatively new mines that were wrought last year, the Appleton and the Loretto. The Appleton was operated only four months in the year, the Loretto for the full year, with an average of 155 men. The ore is a high-grade ore, running some 67% in iron and 0.015% in phosphorus.

The Penn Iron Mining Company employed 400 men on an average for the year and operated the Curry, the East Vulcan and the West Vulcan mines. The principal producer is the West Vulcan, which is working mainly on a new body of ore struck at the 1000 ft. level of B shaft. This shaft is notable for having at its bottom the best-installed direct-acting steam-pump that is in operation on Lake Superior. It is handling 600 gals. per minute from a depth of 1000 ft. at one lift.

The Aragon mine has had about 250 men at work for the year. The mine is down to the seventh level, 650 ft., and while there is quite a large body of ore in sight, some of it is non-Bessemer. The Aragon, as of old, is still troubled with much water, and handles, including the mine and the overlying swamp, something like 1000 gals. per minute.

Both the Aragon and the West Vulcan are using the filling system in connection with square sets. The ore is roomed out on timbers, and as the room goes up the lower tiers are filled with rock or sand run in through winzes from the level above. After the rooms are filled, the pillars are sliced out from below and filling run in. The pillars shrink down some 20% in the process of extraction.

The Pewabic has been the most extensively wrought mine of the Menominee range. The opening up of No. 2 shaft greatly increased the facility for hoisting and the ore mined for the twelve months ending Sept. 30, 1894, was 259,764 gross tons. Nearly all of this has been of high grade, averaging 67.50% in iron and 0.008% in phosphorus. It required the most careful system of underground and surface sampling and analysis to accomplish this result. The outer limits of the ore body were non-Bessemer, occasionally giving 0.400% in phosphorus. Up to the month of July, while the limits of the low phosphorus ore were being determined, it was necessary to sample and analyze every pile of dirt as it was broken in the stopes before sending it up. During the whole of the season the daily hoist sample was composed of a shovelful from every mine-car, and in addition to that every railroad car that left the mine was represented by a small box of ore, tagged with the number of the car and the date of the way-bill. This car sample was not of necessity analyzed, but stored so that at any time a cargo sample could be prepared by mixing the various boxes representing the railroad cars dumped at Escanaba to fill any particular boat. The Pewabic ore was sold on the analysis of the mining company's chemist, and this was probably the first case of the kind. Usually sales are made on the basis of sampling and analyses

at Lake Erie ports. Mine men are not always satisfied with these results, and probably the care taken in sampling at Cleveland will not compare with the systematic and scientific treatment of this subject as given at the mines. In one case, two cargoes of ore shipped in 1891 were reported back by wire as running some 0.075% in phosphorus. While not using as complete a system as the Pewabic, it happened that the particular ore shipped in these two cargoes agreed with quantities represented by some dozen analyses that had been made at the mine. These averaged 0.045% and also agreed with the stope samples. A vigorous objection to a return of 0.075% led to a second report by the Cleveland chemists, in which the phosphorus was found to be as represented and an excuse offered about new chemicals found to be impure. A case is reported of a sampler walking into a Cleveland office with two cargo samples, one in each pocket of his corduroy coat.

The Chapin mine was idle till May 1, at which time arrangements were made to operate the mine for the summer, though it was still in the hands of the receiver. From that date to Oct. 1 the mine employed an average of 588 men and mined 190,107 tons of ore. During this time a considerable amount of opening work was done and repairs made to the hydraulic plant. The Chapin no longer sends filling down from the old sandstone quarry formerly used, but draws from rock-work and the cave such material as is necessary to fill the hard ore stopes. In mining pillars and in new work in comparatively soft ore the ore is sliced from the top and the gob allowed to cave down. The mine is now out of the hands of the receiver and is being operated by a new company composed of the Hannas and Mr. Chapin. The north vein of ore has shown up very well in iron at the bottom level, and although there is little or no Bessemer ore, it looks as though the mining of low grade 58% ore can be discontinued. D shaft is the principal point of work. The Allis Cornish pump is in continual operation and the endless rope haulage is running on three levels.

The Hamilton-Ludington mine is closed and the shafts filled with water. As will be remembered, after the flood of water these two mines were consolidated and baled out through the Hamilton No. 2 shaft. This baling was done to determine the flow of water in the mines and find if it was excessive. The work proved that the bulk of the water could be taken out in some two weeks at a cost of $5000, and that the regular flow was not excessive. The mines were then allowed to fill up to await an improvement in the ore market. As the mine has nothing much better than a 58% ore carrying 0.070% phosphorus, and is 1200 ft. deep, the prospects for its opening are not encouraging.

In Wisconsin the only mine being wrought is the Davidson by the Commonwealth Company. This mine was opened as an open pit, and as the mine has gone down and under rock it has been worked without timber, the ore from each level being stoped into raises or mills and trammed to the hoisting point.

Passing again across the Menominee River, we come into Iron County, Michigan, and find the Dunn, Mastodon and Columbia, the only mines being wrought, and these employ only 130 men altogether. These mines are all non-Bessemer. The only Bessemer mine in the county was the Mansfield, which caved in during September, 1893, letting in the waters of the Michigamme River and causing a loss of 28 lives.

Taking the Menominee range as a whole, the quantity of Bessemer ore in sight is not large. The Chapin in its early days had much low-phosphorus ore; it is now all non-Bessemer, running at least 0.070% in phosphorus. The Aragon and the Pewabic, which formerly had nothing but gilt-edged ore, now have considerable high-phosphorus ore. The Penn Company hoists from its B shaft at the West Vulcan five different grades of ore, based on various iron and phosphorus contents. The Loretto is a shallow mine and as yet has low-phosphorus ore.

In this connection Mr. Per Larsson, who has had many years' experience on the Menominee, suggests the following explanation of the occurrence of phosphorus. The Menominee ore bodies at some period when the strata were approximately in their present position, were of uniform grade in phosphorus, say about 0.075%. Surface water coming down leached this phosphorus and carried it down to a certain point corresponding to the then water level of the country. Here this phosphorus was deposited. At a certain depth below this point the currents ceased and the phosphorus remained in its ordinary state. This idea agrees very well with the facts. From the surface down to a certain point we have a low-phosphorus ore, running from 0.010% to 0.020%; there then occurs a zone or layer that runs up to from 0.120% to 0.400%. Below this layer we come to the regular 0.075% ore. That phosphorus in hematite ore can be removed by washing is a well-known fact, as has been shown by experiments at the Chapin, Pewabic, Lake Superior, Lake Angeline, and lately from the comparative analyses of churn drillings and the corresponding ore on the Mesabi range. It is doubtful, however, if the principle is of sufficient importance to ever have a commercial value.

MARQUETTE RANGE.

The falling off in work on this range is shown by the reports of the mine inspector. In 1892 the average number of men employed in the county was 7230. In 1893 it had fallen to 5162, and in 1894 to 3505, or less than one-half the number employed in 1892. Much of this is due to the shutting down of the hard ore mines, such as the Champion and the Cliffs shafts; but to a greater extent from the closing of the non-Bessemer producers, and also of the small mines whose fixed expenses were too great to stand the low price of ore. For the last two years the mines have been wrought in a very irregular manner, often closing and opening twice a season.

At the Republic mine nearly all the work is being done at No. 8 shaft, and it is reported that the prospects in that part of the mine are good. This is one of the hard ore mines that was shut down for a year, but was wrought in 1894. In its early history the ore bodies at the Republic were large, but as the mine got deeper they seemed to split up, and at one time, some two or three years ago, the prospects for the mine seemed very poor.

After two years' idleness the Champion mine is about to resume work in a small way. This is the best-equipped hard ore mine on Lake Superior, and at the time it shut down was in shape to mine its ore as cheaply as any property of this class. Like the Republic, the Champion is working a number of small ore bodies, and it is only by exercise of the greatest skill that the cost of the rock-

work required to reach these different ore bodies was kept down to a proper limit. Much of the ore was low grade, although some of it was very high in iron and low in phosphorus. Sorting was necessary, both underground and on surface, some four or five different grades being shipped. The Champion was one of the first mines to take up the question of crushing its ore, and in the last two years a plant of modified Blake crushers has been erected for that purpose. The ore is broken to a maximum size of 3 in. There are no other properties in operation west of Ishpeming except the two above mentioned.

Coming to Ishpeming we find the Lake Angeline, the Lake Superior and the Cleveland-Cliffs the only operators. To avoid misunderstanding, it should be stated that south of the city of Ishpeming there was, some three years ago, a body of water called Lake Angeline, and that the water was at that time pumped out by the three companies owning the land on the shore and the drained land divided between them. These three companies were the Pittsburg & Lake Angeline Iron Company, the Lake Superior Iron Company, and the Cleveland Iron Mining Company. As the Pittsburg & Lake Angeline Iron Company is generally called the Lake Angeline, doubt occasionally occurs as to whether it is the lake or the mine to which reference is made. The Lake Angeline is working the old mine which lies south and west of the lake, and produces both hard and soft ore. The soft ore body is under the hard ore. During the past year this company made a good product from the West End mine. This mine is working on a spoon-shaped basin of ore lying directly south of the main body of ore which is under the bottom of the now drained lake. The major axis of this body is about 800 ft. and the minor 300 ft. The ore averages 75 ft. wide around the rim, and the center is filled with soft ore jasper. The main shaft is sunk in the greenstone north of the ore, and two levels are opened up. The first lift has an average of 75 ft. of ore between the level and the sand. A main level, elliptical in shape, has been run around in the ore body and a cross-cut driven from the north to the south rim immediately opposite the shaft. At about equal distances of 100 ft. apart two compartment raises have been put up to the sand and then the ore mined out by the top-slicing system, allowing the sand and capping to cave in and fill up the slices. Some difficulty was found in the beginning in getting this central mass of jasper capping to cave, but after doing some drifting in it and setting off large blasts, it was brought down and the gob followed down in a very tractable manner. In working out a slice the following is the method: From the top of the raise a drift 7 by 8 ft. is driven 50 ft. each way. Here it either meets a drift from the opposite raise or else gob, whence the ore has been mined from the adjoining raise. This level is provided with a small car carrying about 1500 lbs., and mounted on light rails. The drift is kept as nearly as possible between the foot and hanging walls. From the end of the drift a cross-cut is driven to the walls, taking out a cross section of ore 7 by 8 ft. One side of this cross-cut is flush with the gob, the other against solid ore. Six to 10-in. timbers are used, placed from 2 to 4 ft. apart in sets of two legs and a cap. The miners drill and blast the ore, load it into the small car and deposit it in the chute at the raise. After the cross-cut is driven, both toward the foot-wall and the hanging, the floor is covered with timber and then the legs and caps are shot out in order to bring down the gob. This bottom lagging to the cross-cut is made by laying

three 8-in. round stringers along the length of the opening, one in the middle and one on each side about a foot away from the bottom of the legs. These stringers are then covered at right angles with the usual split lagging, placed close together. When the place is caved in this lagging does not break, and on removing the next slice below, instead of having to drive back-lath or poles one finds the stringers in place ready to be supported by the caps of the drift sets. This seems to be a great improvement on the former way of covering the bottom with sawmill slabs. It is not only safer for the men but cheaper in putting in.

This ore body is not uniformly low in phosphorus. Its runs from 0.025% to 0.090%; and consequently great care must be taken to keep this 0.090% ore out. To this end the raises are carefully sampled as put up, and during the slicing each working place is sampled every other day. This sampling and analyzing is under the care of the mining engineer and the results of treating the problem in a careful way are well shown in the analyses of the different grades of ore in stock pile or railroad cars. The necessity of keeping the ore graded is one of the reasons that in mining each slice is just the thickness of the opening in the drift and cross-cut. No back is left to be run down. As a general thing in the caving system a 10 or 11-ft. slice would be removed by 7-ft. openings, the top 3 ft. of ore being run down on retreating, but in this case it is necessary to take the ore from the point where it has been sampled.

All timber for the slicing has to be hoisted up the raise. This at present is done by hand, but a portable electric hoist is under trial. This is run on the mine track from raise to raise by chain gearing from the motor to the wheels. Power is taken from the trolley wire belonging to the tramming plant. When a raise is reached, the machine is clamped to the track, the motor thrown off the wheel gear and connected with the drum, and after carrying the rope to the top of the raise the machine is ready to hoist timber. Some two years ago electric tramming was introduced into this mine and the management seem well satisfied with it. The generating plant is in the engine-house on the surface, along with the hoisting engine and air compressor, and is attended by the one engineer in the room. Brakemen are there of course to run the drums. The engine is a 14 by 30 in. Reynolds-Corliss and by belt runs a T.-H. shunt-wound motor. The voltage is 550, revolutions per minute 900, winding and wiring for a 10% loss. Two motors are in the mine, one a spare. They are the iron-clad water-proof turtle-backs, and handle 6 cars carrying 2½ tons each. With this load about 30 to 40 ampères of current are used. No particular novelty is shown in the construction of the trolley line save that the wire, No. 0, is covered by a 12-in. tarred board with strips on its edge. This is fastened to the under side of the caps and protects the wire from dripping water. The rails are bonded in the usual way and connected with a No. 0 ground wire. The trolley is of the diamond pattern. Two men are employed, a motorman and a switchman. The motor runs out with a trip of 5 or 6 cars and spots them in one drift of the mine, then runs to another drift and collects a trip of cars that have been filled at the chutes and leaves them at the shaft. This process is repeated at all the various parts of the level. Between times a trip of flat cars loaded with timber is taken out and left under the various raises to be unloaded.

The cost of tramming the ore is 2c. a ton, the cost of loading the ore from the

chutes into the cars, and from the cars at the shaft into the skip, is 3c., so that the total cost of handling ore and timber from chute to skip is 5c. per ton. If this were done by hand it would probably cost at least 12c. per ton. The product handled is about 15,000 tons a month. When the plant was first installed, one or two miners carrying drills on their shoulders were shocked by allowing the drills to touch the trolley wire, and a few inquisitive people tried the experiment of touching the live trolley wire with their iron candlesticks. No serious harm was done any one, but care is now taken to avoid contact.

The Lake Superior Iron Company has been operating its hard ore mine, its hematite mine the eastern end of which is under the dry bed of Lake Angeline, its Section Sixteen mine, which is the western extension of the Lake Angeline hard ore and doing some work on its Section Twenty-two mine, which is on the hanging side of the old Winthrop mine, two miles north of Ishpeming. The mining work is done in the usual way, the work in the hard ore being confined to the removal of pillars by slicing from below and running in filling, the rooms having been previously filled.

At Section Sixteen a new 40-drill compressor is installed. It is a cross-compound Corliss, with two air-cylinders provided with positively actuated inlet valves. The outlet valves were originally provided with an automatic trip, but this has been discarded. The compressor mentioned runs on 130 lbs. steam, condensing, and is reported to produce its air at one-half the cost of the slide-valve compressors in former use.

As an index of the trend of pumping practice on Lake Superior it may be mentioned that at Section Twenty-two the company has just put in a direct-acting compound condensing steam pump. The Lake Superior Company has both Cornish and steam pumps in use, and taking everything into consideration it prefers steam pumps to the Cornish. The efficiency of a good steam pump will probably run from 12,000,000 to 20,000,000 foot-lbs. per 100 lbs. of coal; an ordinary Cornish pump runs from 50,000,000 to 60,000,000 foot-lbs. Still it must be remembered that coal is not the only item to be considered. It seems strange that no one on the lakes has tried direct-acting pumps with high-duty attachments, such as the Worthington people make; these pumps have given on a test run a duty of 124,500,000 foot-lbs. per 100 lbs. of coal; total steam used per pump horse-power was 16.8 lbs.

The Cleveland-Cliffs Company during the last year has been rather unfortunate in being the possessor of more non-Bessemer properties than were desirable. The hard ore mine inside the city limits has been closed for over a year. The Lake mine has been working in a small way with occasional spurts to test the capacity of the plant for output. The Lake mine has been described many times, and is certainly a very fine body of ore, and opened up so that a product of a million tons per annum could be achieved. Unfortunately the phosphorus is above the Bessemer limit, running about 0.100%. The ore body is in a large diorite basin and is spoon-shaped, the central portion being jasper. The mine was opened up on the first and second levels while the lake above was filled with water. The water having been pumped out, there remained a deposit of mud in some places 20 ft. thick. The fear of this mud has prevented any exploitation that would lead to caving, and so the mining has been continued on square sets on the second

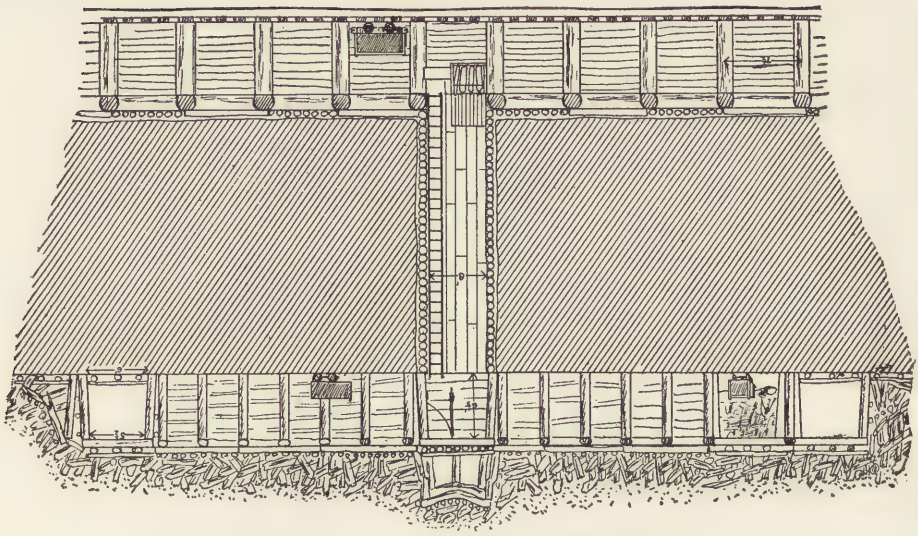


FIG. 1.—LONGITUDINAL ELEVATION.

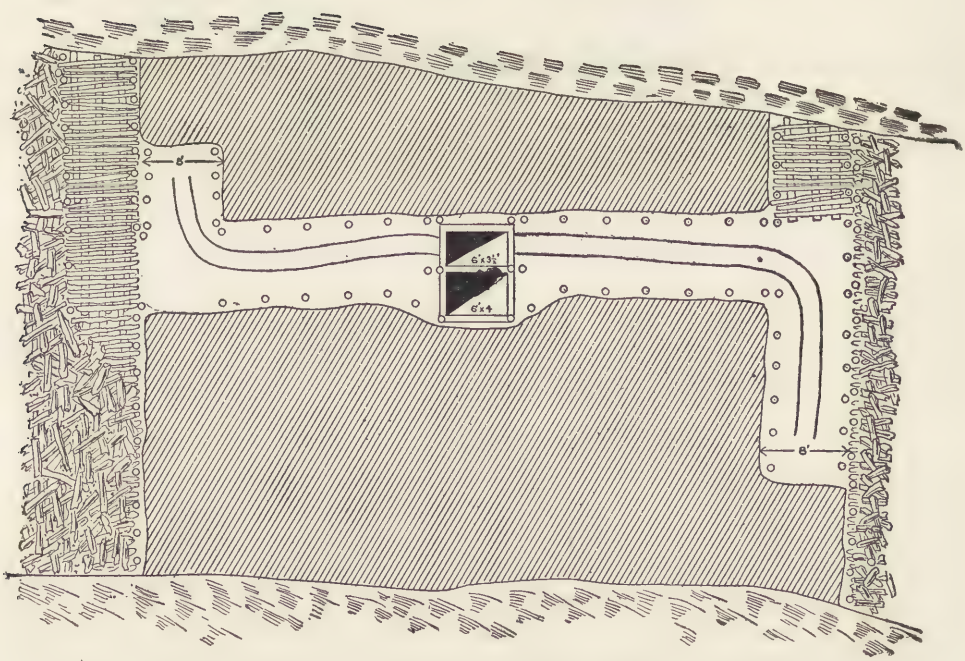


FIG. 2.—PLAN OF TOP SLICE. TOP SLICE SYSTEM OF CAVING.

level, the rooms being filled. At the east end of the deposit the ore is covered by some 30 ft. only of glacial drift. This is now being stripped and the stripping milled down a raise to the first level of the mine. Here it is loaded into cars and trammed to various points over the rooms on the second level and dumped.

The tramming at the Lake mine is now done by an electric plant similar in plan to that at the Angeline. The ore cars, however, are of a new construction for the district. They are of steel, quite high, and carry 3½ gross tons of ore. Instead of being end-dumpers, the bottom is provided with doors, and at the shaft the cars are slowly shunted along at right angles to the line of the main inclined hoisting shaft and dumped into an underground pocket. From the pocket by means of a suitable loading chute and door the skips are quickly loaded. The hoisting engine at this shaft is the only cross-compound first-

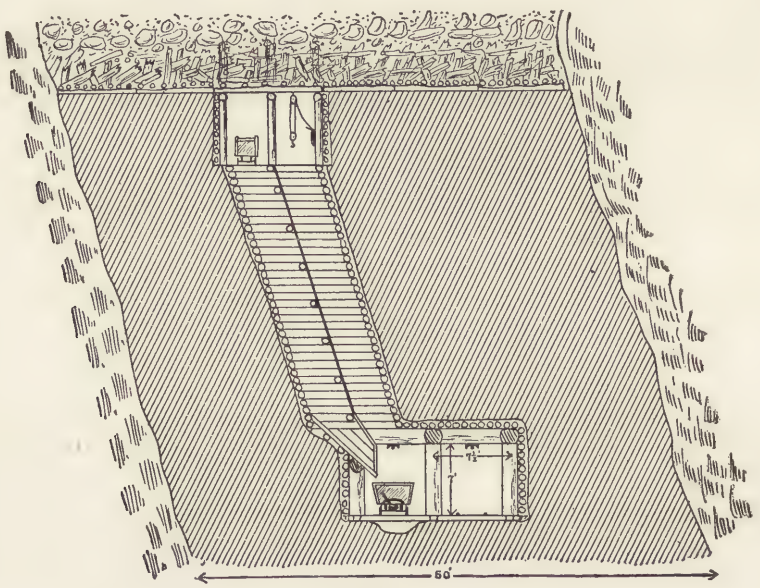


FIG. 3.—CROSS SECTION. TOP SLICE SYSTEM OF CAVING.

motion plant on the lake. It is made by Bullock and winds with a 10-ft. drum, two skips in balance. The drum is made in halves, one of which is keyed to the shaft. The other half is loose on the shaft but bolted near the rim to the keyed half. This permits of a relative adjustment of the two hoisting ropes and obviates the necessity of two clutches and their usual mechanism. It, however, necessitates the empty skip going to the bottom each time. No gates are used for the skips to rest on, as they hang by the rope in the shaft. To give the engineer control in this particular an indicator has been put in, where a long pointer swings over an arc to indicate the position of the skip not only as it comes into the dump but also at each level. The indicator mechanism is also connected with a device to prevent overwinding. The saw and tenon mill at this mine is very complete and economical. The mine closed

down on the first of this year and future work will depend on the condition of the ore market.

The Cleveland Hematite, or old Nelson mine, was wrought during the past year, but is now closed. Its one shaft reached a depth of 1000 ft., but failed to open up any ore, the bottom being found between the 900 and 1000-ft. level. Of the other Cleveland-Cliffs mines, the Foster and the Cliffs shafts are shut down and full of water, while the Salisbury, which produces a good grade of Bessemer ore, has been steadily wrought. The peculiar vagaries of this ore body necessitated the bodily removal of the hoisting, compressing, pumping and boiler plant, together with their brick buildings, last spring. This was effected with great expedition and without flooding the mine, and now it is hoped that the plant is founded on a rock. Hematite mining has developed the fact that a rock, in the sense mentioned by Peter, may often prove sand, particularly if it is hanging wall or capping.

Proceeding toward Negaunee we find the Jackson doing a little work at its west end. The Negaunee mine has also been steadily at work. The Blue ran nearly all the year, but it is now shut down. The Lillie, Cambria, and Davis have all done some work.

At the Buffalo mines the work has been concentrated at the new find near the mine office. Here within ten months a new mine has been opened up and a large product obtained. Much of the ore is Bessemer, but not all, and five grades are produced. This mine is worked on the caving system, slicing the ore from the top and allowing the gob to follow down. In opening up the first level under the sand and gravel square-set rooms were used. These were worked out to the sand and then caved full. This so disturbed and started the overburden that there was no difficulty in slicing out the pillars in the usual method, and from thence on the way has been simple. The Buffalo group, under Mr. T. F. Cole's management, were the first large mines to use the caving system in Marquette County, and the results in economy, safety, and the removal of a large percentage of the ore, have been very satisfactory. The other mines of this group are in good shape for a product and are ready when the demand for a non-bessemer comes.

On the Cascade range, south of Negaunee, the Volunteer and the Platt have been at work. The Platt has some very good Bessemer ore. Down the line near Swansey the Escanaba mine has been doing a little. This mine, so reports say, has a very fine body of Bessemer soft ore, and it is rumored that the Norrie people are going to operate it. The Wheat mine has a few men at work.

Outside of the Pittsburg & Lake Angeline mine, the Salisbury, and Section Sixteen of the Lake Superior, there is not much Bessemer ore on the Marquette range. New discoveries are in order and will pay to operate if found.

The Cleveland-Cliffs Company is building a charcoal furnace plant at Gladstone, a town near Escanaba, Mich., which is the main shipping point for the Chicago & Northwestern Railway on Lake Michigan. This plant is not intended to consume the bulk of the Cleveland-Cliffs ore, as has been very erroneously reported. It will have a maximum capacity of probably 100 tons a day.

VERMILION RANGE.

There are but three mines on this range—the Minnesota at Tower, and the Chandler and the Pioneer at Ely. The Minnesota produces hard ore and is well planned and equipped for economical operation. The shafts are in the foot-wall, and while on an incline of about 80°, are provided with cages. The present method of breaking ore is by overhand stoping and filling with waste rock. A lift of 100 ft. is sunk, a plat cut and a cross-cut driven into the ore; the whole vein, which varies from 10 to 90 ft. wide, is then cut out full width and drift stopes carried in both directions along the strike and about 18 ft. high. Every 50 or 75 ft. raises are put up to the next level. When the stope has been advanced a sufficient distance, heavy drift sets are erected along the middle and lagged and spiked together. Filling is now run down one of the raises and that

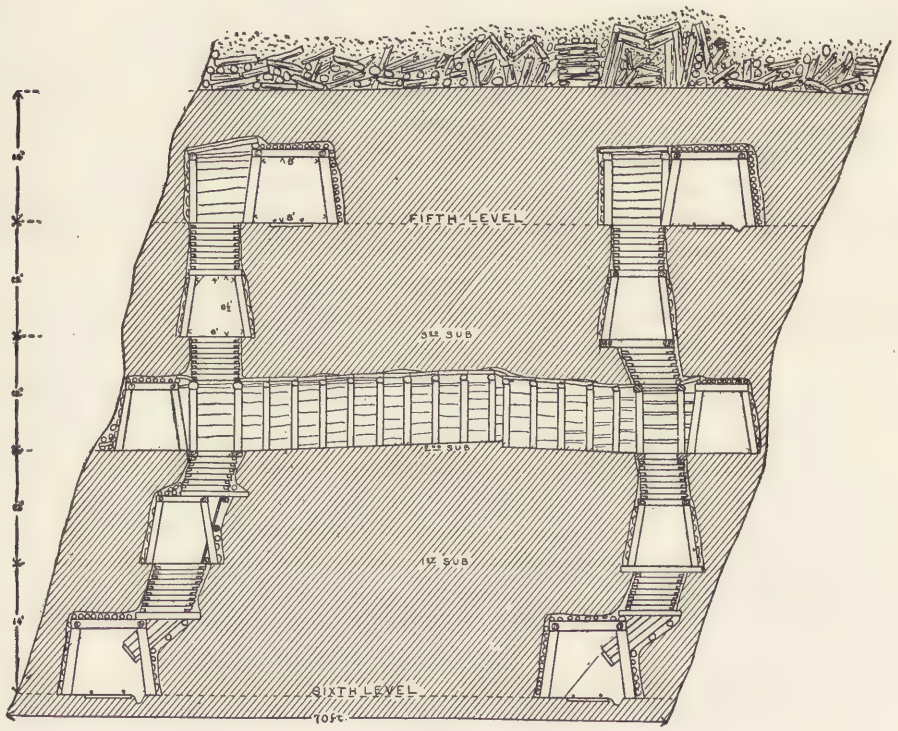


FIG. 4.—CROSS SECTION. SUB-DRIFT SYSTEM OF CAVING.

portion of the stope tributary to the raise, and in which the timbered gangway has been formed, is filled with rock and leveled off about 6 ft. from the back. This means 12 ft. of filling in height, and allows a covering of 4 ft. over the gangway timbers. In order to distribute this rock properly a small car is put up on top of the filling as soon as enough material has been run down to get a start. When the car is up, the raise is blocked by a chute at the bottom so that the filling can be run in the car as desired. When the gangway timbering is being done, chutes are built in 25 ft. apart and cribbed up so as to be flush with the top of the filling. As will be seen from the above description, we have a stope

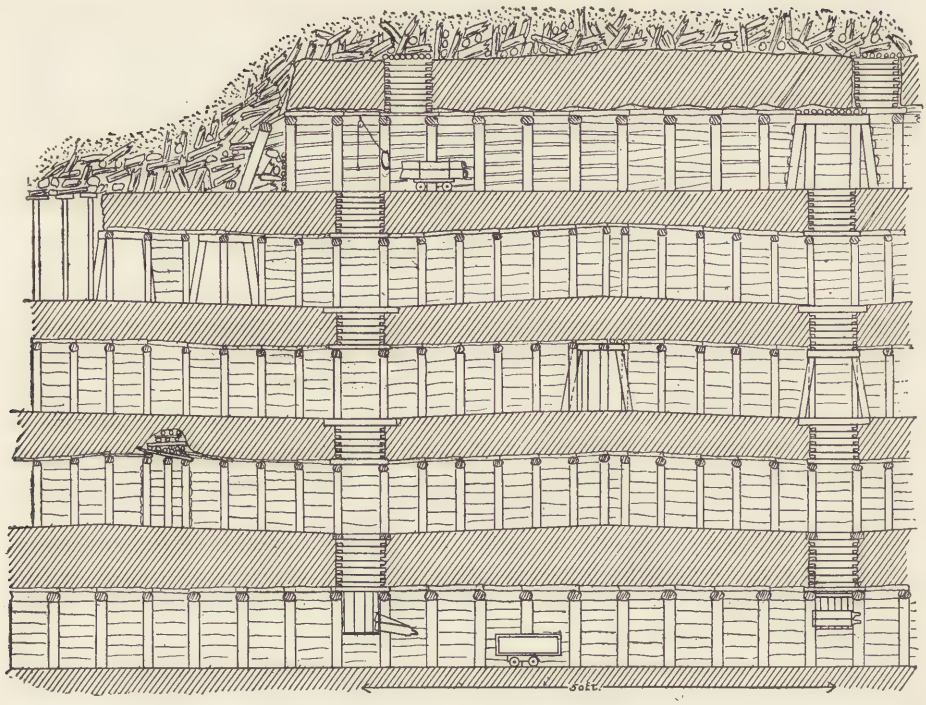


FIG. 5.—LONGITUDINAL SECTION.

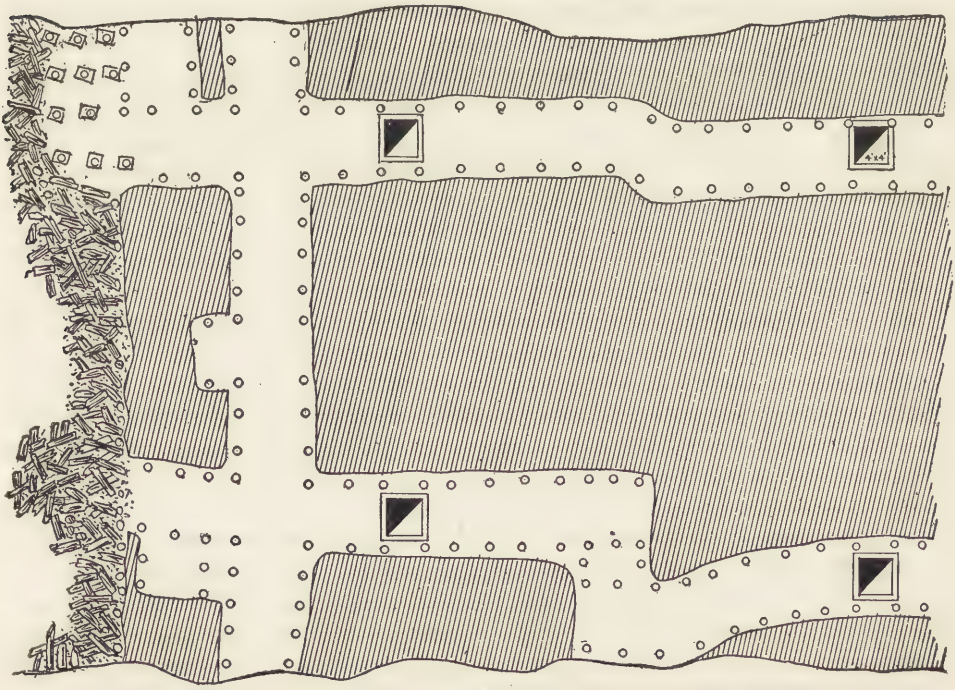


FIG. 6.—PLAN OF THIRD SUB-DRIFT. SUB-DRIFT SYSTEM OF CAVING.

18 ft. high, the bottom 12 ft. of which is filled, and the top 6 ft. open. As soon as the ground floor stope is advanced sufficiently a second stope is started, carrying a back of perhaps 10 ft. The ore is broken down upon the filling below, blockholed, sledged and shoveled, or thrown into the chutes. As soon as this stope is advanced sufficiently it is filled up with waste rock from the open pit, leaving an open space of 5 or 6 ft. on top to allow for the passage of the waste-rock car, and for starting work in the next stope. This system has been in use for over four years and is very satisfactory. In this stoping the holes are dry, drilled with precussion drills. They average 9 ft. per shift. Lately an "E" Sullivan diamond drill has been used with considerable success, two holes 18 ft. deep being sufficient to carry a stope 40 ft. wide. About 18 ft. a shift is the usual rate of drilling with the diamond drill. For the percussion drills round 1⅛-in. steel is used, and two or three mines have finally adopted round steel in preference to octagonal or some of the fancy cross sections. The drill chucks are bored out so as to accommodate the bushing and the full size of the steel. This saves the necessity of turning or forging a shank on a drill. Some people turn shanks on a drill, but the practice is inexcusable.

The Minnesota has during the last year installed a plant of six crushers to reduce the ore to a maximum size of 3 in. Situated as the shafts are on a hillside, the mine cars can be run by gravity to the screens at the head of the crusher house, thence by gravity the ore runs through the house and out either to the stock pile or the railway cars. It was soon found that Minnesota ore was a much harder material to crush than Calumet conglomerate, and face plates of hard iron from the copper country foundries were rapidly worn out. Many different kinds of material were tried and the results of experiments on different iron and steel for face plates may be given hereafter. The Minnesota mine is an example of the best practice in Lake Superior hard ore mining.

The Chandler mine at Ely is operating on a body of ore whose physical characteristics are peculiar. It is a hematite which in the cars appears like an ordinary dark-blue hematite. Instead of carrying 10% to 12% of moisture, however, it does not run over 6%. On close examination it appears to be a hard ore that has been so shattered that it is broken down into small particles. About 20% of the deposit in the mine is hard and solid in place and has to be drilled and blasted almost like ordinary hard ore. The system of mining employed is what is known as the sub-drifting method of caving. This system was first used on Lake Superior in the Brotherton mine in 1886, and it has been followed there with great success. The Chandler ore occurs in a trough pitching toward the east at about one in four. The ore runs up on both sides of the trough and the center is filled with rock. The ore in each leg of this trough is probably 70 ft. wide. Vertical shafts have been sunk in the rock on either side of the trough and lifts formed on an average of 50 ft. apart. Cross-cuts are then driven out to the ore and by a system of curves and switches the main levels are driven in the ore body. On an average two main gangways run along on each level, one near the foot and one near the hanging wall. Every 50 ft. along the main levels raises are put up, the first 6 ft. is cribbed, and then the raise is enlarged and a couple of drift sets put in and lagged nearly over. From this point the sub-drifts are started in each direction to meet corresponding sub-drifts from

the adjoining raises. As soon as the first "subs" (for so the miners call them) are well under way the raise is continued another 4 or 5 ft. with cribbing, a second place is enlarged and the second sub started. The third sub is started in a similar manner and then the raise is holed into the level above, care being taken to have it come out one side of the main track. The ore from the subs is shoveled in the raise, which is provided at the bottom with a chute and stopper. When the distance from the raise to the face of the sub-drifts is too far, wheelbarrows are used. These subs are given a pretty stiff grade so that the wheeling is easy. The raise is pushed up as rapidly as possible so that ventilation may be afforded, and the timber for the sub-drifts is lowered down instead of being hoisted up. The sub-drifting is the preparatory work and is carried on above the lowest level of the mine. As soon as a lift is sub-drifted it is easy to see that it is divided into four slices of about 12½ ft. each, and that each slice has a series of drifts in it, say 7 ft. high with 5 ft. of a back over them and numerous blocks of ground between the various drifts. The plan of the ore on each slide is determined by numerous cross-cuts from hanging raises to foot raises and from rock wall to rock wall. The next process after the "sub-drifting" is the "stripping." Stripping is the process of removing ore from the various slices in a descending order. If we assume that the fifth lift has been stripped and caved we mean that all the ore has been removed down to a plane corresponding to the floor or bottom of the first sub-drift above the fifth main level. This leaves the fifth main level open protected by a back of some 6 ft. of ore. In order to stope the sixth lift we go to the end of the fifth main level and by a series of drifts cut the ore up into small blocks of say 10 ft. square. The superincumbent mass of refuse crushes down the 5 ft. back, splinters the pillars, and they can be readily pulled away with pick and bar without the use of powder. In cases where the ore is softer it is taken out by parallel drifts or cross-cuts similar to the manner mentioned at the Lake Angeline East End. But in all cases there is the usual back of ore between the top of one sub-drift and what was the bottom of the next above. Sometimes it is necessary to support for the time being the mat of timber above by long props with head-boards. When the stripping on the fifth main level has retreated a sufficient distance that operation is begun on the third sub-level of the sixth lift, and so on successively till the first sub-level is stripped. The main level of the sixth lift, however, is left so as to give access to the seventh lift with timber and air. In stripping the sixth lift, all the ore from the back of the fifth main drift to the back of the sixth main drift is shot down the raises and trammed out through the sixth level. The usual plan is to have one lift in process of stripping, one lift being sub-drifted and the shafts being sunk for the next lift. As the tonnage per man per day is not so great when sub-drifting as when stripping it is usual to do sub-drifting during the winter season when shipping is stopped and the ore must be stocked. Stripping can then be rushed during the shipping season.

In all this work light timbers are used and much of the lagging used is saw-mill slabs. It is useless to try and use this system without light but close timbering. Things must be completely under control and this cannot be done by having untimbered drifts. In several cases, lulled by a false sense of security, the caving system has been attempted with insufficient timbering, and when the inevitable day of reckoning came the system was condemned.

The Chandler mine is now down some 500 ft. and the side pressure even from the foot wall begins to show itself. This has led them in sub-drifting to omit to drive the first sub over the main level until stripping is about down to that slice. This gives a back of at least 18 ft. over the main level and saves repairs to the timbering of the main gangway. To effect the same result at the Chapin when rooming, the rooms are begun 30 ft. above the bottom of the level and this 30 ft. is taken out from the next level below. At the Chandler, if crushing destroys a main gangway, the ore can always be shot down to the next gangway, 50 ft. below.

The Chandler mine may be considered a typical example of how to work a soft hematite body of ore when the problem is not complicated by having to grade the ore for phosphorus. It is reported that during the winter of 1893–94, when it was with the greatest difficulty that money could be secured to operate the mines, that the output per man per day was nearly 5 tons. This was with hand tramming and included everybody under and above ground. The advantage of the sub-drift system in a mine where the ore bodies are irregular was very evident when tried in one instance in a mine which had been started on square set rooms. The ore mined in the rooms ran between 59% and 60% in iron. By changing to the sub-drift system it was found possible to run the grade up to 63%. The reason for this was that in sub-drifting one could swing to the right or left and leave a finger of soap rock or a stringer of quartz, or if it had to be broken down when stripping it was easy to stow it away in the gob.

The advantages of the sub-drifting system of caving over the top slice caving system are as follows :

1. The ore body is more thoroughly explored by the raises and drifts than by the simple raise of the top slicing. Lateral tributary ore masses which may be separated from the main body by a thin layer of rock are less likely to be missed, and when found can be stripped in parallel with the main body. If these bodies should be discovered when the lift was half sliced out, its uppper portion would in all probability have been caved and mixed with the gob.

2. Nearly all the timber can be lowered down through the winzes from the level above and pulled into the working place, thus saving the expense of hoisting up. In addition to this, most of the timber will be handled on a level where ore-tramming is not in progress and no interference follows.

3. Ventilation is much improved by the numerous channels open, and not only are the men's health and comfort improved, but an actual saving in time is effected by the more rapid carrying away of powder smoke.

4. And this is of the greatest importance—the miner has as a general thing more than one raise out of which he can escape in case of any sudden fall of ground.

During the six years from Jan. 1, 1887, to Jan. 1, 1893, at which latter date the mine closed, the Brotherton produced 432,139 gross tons of ore with an average underground force of 132 men. All this ore was mined on the sub-drifting system of caving, and not a single man was killed. There being no statistics kept in Minnesota, I cannot say how well the Chandler mine has fared, but I understand the record is very good.

In working the top slicing, or north of England caving system, it is not neces-

sary to have the back of the drifts immediately under the mat of timber, as is done at the Lake Angeline. The back of ore may be increased according to the hardness of the ore.

The Pioneer mine adjoins the Chandler on the east and after considerable scattered work has at last reached the Chandler lens by a deep vertical shaft and cross cuts.

MESABI RANGE.

There have been so many descriptions of the occurrence of the ore bodies on this range that it will not be necessary to go into that point at any length. As a rule the ore is found in nearly flat bodies, averaging 80 ft. thick and extending in horizontal directions from hundreds to thousands of feet. This thickness of 80 ft. is nearly correct, although it is claimed at Virginia that the Oliver is 300 ft. thick at the center. If this is so, the ore must exist in a pitching trough.

The mining on this range may be divided into three classes: 1. Open-pit work. 2. Underground work. 3. A combination of the two, called the milling system.

1. *Open-pit System.*—The open-pit work is usually done with steam shovels. The slope of the ground being generally to the south, surveys are made in that direction, and at a certain point a cut is started running north, of sufficient size to accommodate the shovel and its train of grading cars. This cut is advanced either on a level or on a slightly descending grade, if water is not feared, till the ore level is reached. The grade is then changed, so as to run along on top of the ore. After this thorough cut is carried in as far as it is desired to strip, the shovel is moved back to where the ore was first encountered and a second side cut begun along the thorough cut. In this way, like the ribs of an opened fan, the drift over the ore body is removed. As this stripping work is advanced a gang of men follow the side of the cut away from the steam shovel and with picks and shovels thoroughly clean the top of the ore of such gravel or dirt as may be left. It must not be supposed that the plane between the ore and the drift is a regular one. It is not, but consists of many depressions and ridges. A general average must be struck, and occasionally some ore is removed in the stripping. This is particularly the case when the top ore is lean. A sufficient space having been stripped, a second shovel is started at the point where the ore was struck, to make a thorough cut in it. A very good plan is to start ahead with a shovel and waste the ore removed on either one side or the other of the cut. When this cut is advanced sufficiently, the shovel is moved back to the starting point, a track laid in for empties, and a cut is taken from the side where the thorough cut ore was wasted and the ore loaded on the railroad cars. When the cut becomes high, it is impossible to work in this way, and the shovel must work against the face of the advancing thorough cut. This of course requires railroad cars to be spotted one at a time. When once the thorough cut is in, the ore is taken off by side cuts similar to ribs of a fan, as mentioned in the case of the stripping.

In stripping much hard pan is encountered and blasting is resorted to, for the purpose of shaking it up, and also to loosen up the ore, when that is being

removed. Holes are drilled in the ore by hand, two hammers on a drill. As the ground caves considerably, it is quite common to simply drive a pointed drill down and then pull it up with a clip and a couple of bars. The hole, when at a proper depth, is shaken two or three times with dynamite cartridges and finally charged with black powder. As a rule, the distance apart of the holes, their depth and their distance from the face, are about equal. In high faces 25-ft. holes are often put down. The drilling of holes with collar on the face of the slope is occasionally done, so as to keep the face nearly perpendicular. Good work consists in always having a pile of loose dirt at the foot of a pretty steep slope. It is estimated that the cost of explosives will not run over 3c. per ton. At some properties the face on the cut gets very high. This is not desirable, as slides of ore come down and bury up the tracks and sometimes the shovel. About 18 ft. is the most advantageous height of cut, and if there is 30 ft. of ore it would be better to remove it in two cuts than in one. Many of the steam shovels used are too light for the work.

Many railroad contractors found by trial on the range that frozen hard-pan at 30° F. below zero, was different material to handle from sand in a railroad cut. Contracts for stripping run from 30c. to 50c. a yard. Some properties are doing their own stripping, some of it for 20c. a yard. The practice in handling material seems to run toward large cars and heavy rails, particularly the latter.

The main objection to the steam shovel system of work is the cost of the approaches, which vary from 500 to 1000 ft. in length. As they get deeper in the ore, these cuts will have to be deepened, or else a zigzag system of tracks used. At present the shovels are loading from 1200 to 1800 tons each per shift. The best run noted was in October, 1894, at the Mountain Iron, when in ten hours a shovel loaded 143 cars of 23.5 tons each, or about 3200 tons. This mine was open cut at both ends so that there was no lost time "spotting" cars.

In regard to the cheap ore, of which we have heard so much, it may be stated that last spring a contract was taken at the Biwabik mine for a period of five years to mine 1,000,000 tons a year. The price reported was 21½c. per ton of ore shipped, this to cover the cost of stripping and mining. It is stated that after a season's work the contractors have thrown up the contract. It is reported that at the Oliver mine the cost of putting ore on the cars is about 30c. a ton.

2. *Underground System.*—In underground work there does not seem to be any settled opinion as to the best method. Rooms on square sets and the North of England caving system have both been used. Some places have been worked on no system at all, and shaft-houses standing on pinnacles surrounded by caved tracks show that proper care has not been taken in laying out work. The problem of laying out a plan of work and equipping a Mesabi mine is much simpler than on the older ranges. A few months' careful work with test-pits and drill-holes will give a very accurate idea of the extent of the ore body, and of the approximate location of the different grades of ore in that body. It will show the depth of covering and the point below which water will be encountered. It will give an idea of the physical characteristics of the ore and covering, which will determine to a great extent how the ore had best be broken. It is much better to experiment with the drawing-board and the figuring-pad than with the mine itself.

In determining whether a mine shall be stripped or opened up underground, we have two factors on the Mesabi that do not always occur: one is the extreme cold and long winter season, and the other the occurrence of layers of Bessemer and non-bessemer ore that should be removed separately. These two factors, when considered, may at times throw the scale in favor of underground work.

When it is finally decided that underground work is to be prosecuted, the first consideration is the location of the shafts. We have here a choice between two systems: first, plenty of shafts and short underground trams, or else a few shafts and long tramming, probably with cable or trolley. Although each deposit is a problem by itself, it is probable that a number of shafts will be preferred in some cases. The hoisting machinery could be placed in position on the south or down-hill side of the ore body, and each plant operates two or three shafts in succession, a new shaft being sunk from 250 to 400 ft. south of the previous one, and the shaft-house moved down when the ore north of the first shaft was exhausted. The levels need not be the same in these shafts, but might be lowered in the south shafts so as to diminish rock work necessary to get at the very bottom of the ore. At some places it is very difficult to get the solid hard-pan at the bottom of the glacial drift to cave down. This difficulty could be overcome by beginning to extract the ore by rooms. A good plan would be, having located a shaft and determined the block of ground tributary to it, to drive a main double-track drift north at the first level, which would be not less than 50 ft. below the covering; use square sets with 7½-ft. centers. When the proper shaft-pillar has been left, start a three-set room each way, east and west, running it out to the boundary. Continuing north in the main drift, leave seven sets for a pillar, and then cut out a three-set room, and so on till the north rim is reached. This work might be greatly facilitated by running a second heading of the main drift from a small shaft at or near its proposed north end, utilizing for this purpose some test-pit and exploring outfit of small portable boiler and hoist. We would now have the ore cut up into 25-ft. rooms and 50-ft. pillars. Along the center of each pillar drive a drift east and west, and every 50 ft. put up a two-compartment raise to the overlying surface. By this time the rooms farthest north should have been worked out and caved down and filled. This would have so shaken up the overburden that the 50-ft. pillars could be taken out, either by the sub-drift or the top-slicing method of caving. Without going into very close calculations, I think an area of 400 by 500 ft. would turn out 1000 tons in 24 hours as soon as it gets fairly under way. Timber should be sent down through old test-pits, and not through the main shaft, except such as was necessary for main drifts.

If objection is made to shafts close together attention may be called to the Norrie, which began with shafts 300 ft. apart, and as it got deeper abandoned every other one. However, the matter is one of calculation, and it must be remembered that interest on capital invested is a large item.

Another plan for handling the ore which might be suggested, is that the ore body be divided into strips 400 ft. wide east and west, and that south of each strip a shaft be sunk. Then drive north a slope on the same grade as the bottom of the ore body, and at the proper points drift east and west for the rooms. The ore would be loaded and trammed by hand to this main double-track slope, and

there the loaded cars gripped to an endless cable and sent down to the shaft The empties would come up on the other track. The direction of motion of the rope would be changed from time to time so as to accommodate either side of the slope without having to switch cars across the opposite track. A road of this kind would run on as low a grade as 4 ft. in 100 ft., without any rope-haulage engine. The average hand tram, with a territory 400 ft. wide tributary to each slope, would only be 100 ft.

In this connection it may be said that the underground system of mining should not be resorted to unless as a last expedient.

The So-called "Milling" System.—The milling system has been adopted in those mines where it was considered easy to strip with either shovel or cart, but where the slope was such that it was not considered desirable to handle the ore with a steam shovel. In practice a certain area is blocked out for stripping, and at a convenient distance a shaft is sunk with two skip roads. This shaft is sunk to a convenient depth, and then drifts are run out in the ore. From the drifts raises are put in the ore to the bottom of the pit, which by this time has been stripped of the overburden. The ore is now underhand stoped into the raise, and falling into a chute at the bottom is loaded into cars and trammed to the shaft. This is a very cheap system, but is not by any means new. In 1886 Mr. Joseph Sellwood employed the same system at the South Vein Colby mine. A large tunnel, sufficient in cross-section to admit 20-ton railroad cars, was run from the side hill along the quartzite foot-wall and in the ore body. At distances equal to two car-lengths raises were put up to the bottom of the stripped pit and the ore was milled down into the cars with but one shift of the train of a car length. It may be mentioned that a train of some twenty railroad cars was one day switched in, loaded and pulled down into the yard in less than one hour. This milling system was used in France in 1884 in the excavation of a 62-ft. cut on the railway from Saumur to Chateau-du-Loir.

There is one advantage of the milling system in cases where dump room is limited, and that is that after the ore is removed from a block of ground, that space can be filled with stripping from the adjoining block. This method was employed in Kettering, in Northamptonshire, in 1889. In that pit 15 ft. of overburden was removed by hand labor so as to get at a 12-ft. bed of underlying ironstone. At the Penrhyn slate quarry in North Wales the overburden is removed, as is also the slate, by a series of steps 60 ft. high and 30 ft. wide.

The Mines of the Mesabi Range.—Of the mines tributary to the town of Biwabik the Hale is the most eastern that is wrought. The ore is non-bessemer, but is rather harder than the average, and so sells. It has been stripped by hand into grading cars, and the ore is removed by means of a Hayward self-acting dipper operating on an overhead cableway. The span is some 150 ft., and on each side is a tower mounted on trucks and laid on a track. The south tower is, in addition, provided with a pocket to hold ore, a boiler, and an engine to operate the various cables. In operation the ore is blasted down from a north and south face advancing east. The ropeway is left in line with this face a little to the west, and as the self-acting dipper is lowered upon the broken ore it picks up its load as the closing rope is hauled in, rises to the main cable as the closing and hoisting ropes are pulled in unison, and advances to the pocket

as the traveling rope is thrown in gear. At the pocket the letting out of the closing rope opens the bucket and the ore is discharged. This system, which is applied on the range at the Hale mine alone, offers many possibilities, and there is no doubt that a carefully constructed plant on this same general system would operate quite well.

The Kanawha and Shaw have not been worked. The Cincinnati, covering five forties, has been opened by shafts, but was idle all last year. It was on Cincinnati ore alone that the Duluth furnace ran in the winter 1893-94.

The Biwabik has been in difficulties, and only shipped some 90,000 tons of ore last year. It is reported that the contractors have abandoned it, but that it will be put in shape for work next year. This must be done, or else the cuts will cave in and fill.

The Berringer was not worked last year, but during the previous year mined on the milling system. It is said that when once stripped the daily output per man per day was 16 tons.

The Canton is a strictly underground mine, working mostly on rooms with square sets. The ore is hoisted from two shafts south of the workings. It can easily produce 25,000 tons per month. They are sinking a new shaft south and west of the present workings. The McKinley is shut down.

At Eveleth the only shipping mine last year was the St. Clair. The output was small and was mined underground. The Adams at this place, operated by the Consolidated, is to be wrought on the milling system, and is now being stripped and got in shape. It will be a producer in 1895.

Coming to Virginia, we find a large group of mines. The largest is the Oliver (formerly Missabe Mountain). This mine, an open one, is operated by two cuts running parallel toward the southeast. The stripping is about 20 ft. in each cut, and in the middle it is at least 40 ft., the drift running down and making a trough. It was this unexpected depth at the center that obliged the ore to be wrought in two pits. The side stripping is completed up to the Lone Jack line. At the quarter corner between sections 8 and 9, T. 58 N. R. 17 W., there come together the Oliver, Lone Jack, Ohio, and Moose, being respectively northwest, northeast, southeast and southwest of the corner. Arrangements have been made with the Lone Jack so that its ore will be mined by the continuation of the Oliver cuts, and I believe negotiations are in progress for similar action in case of the Ohio and Moose. The Moose has but little of this ore body. The approximate width of the body is 500 ft., and its thickness, so I am informed, has been proven to a depth of 300 ft. in the center. This winter a shaft is being sunk to determine the lateral extent of the body and make provision for pumping in case mining is done below water level. The Oliver ore body continues over the Lone Jack and Ohio, and it may prove to be the same body as is opened up at the Norman, though in a line between the Ohio and the Norman a great many pits have been bottomed in jasper (taconite).

The Norman on the N.E. ¼, S.W. ¼, section 9–58–17, is operated by the Minnesota Iron Company on the milling system. The stripping was done by teams, as there was no chance for the disposal of the dirt by use of a level cut. A space some 200 ft. square was stripped. Mining was carried only about half the season, hence the small output.

The Franklin, just north of the Norman, is operated by two shafts on the caving system. Timber is sent down through old test-pits that were sunk in the ore. In October they had about 450 men at work and were getting out 1550 tons a day. This is a very good product per man for an underground mine.

The Commodore was idle all last year. It was wrought the previous year on the caving system from two shafts. It is reported that much of the ore from this mine is non-bessemer.

The Shaw and the Moose cover the southeast quarter of section 8, and about equally divide a body of ore some 400 ft. wide running along the east-sixteenth line of the section. The ore is not very high grade, as far as has been shown up. It is now being drilled. On the Moose was found some manganese ore, but it was in pockets and high in phosphorus.

The Minnewas, owned by the Consolidated, is a small underground property operated by a double-cage shaft. It was idle all last year, simply shipping a couple of thousand tons of the previous year's stock-pile.

The Auburn, owned by the Minnesota Iron Company, has been operated on the milling system with great success. The surface slopes to the north at a pretty fair rate. An area of some three acres was stripped with a steam shovel, the dump being to the northwest. South of the pit a shaft on a slight incline was sunk and provided with two 3-ton skips. The level is some 150 ft. below the collar of the shaft. The stripping varies from 18 ft. at the west end to 30 ft. at the east end of the pit. The hoisting engine at this mine, made by E. P. Allis & Co., is worthy of mention. The drum is 6 ft. diameter by 5 ft. face. This is attached by a band clutch with 10-in. face to the 8-ft. gear. This gears with a 2-ft. pinion on the engine shaft. The brake band is of 12-in. face. The two cylinders, set on quarter stroke, are 16 by 36 in., of the usual Reynolds-Corliss type, but without a variable cut off. The engine is reversing by the tumbling miter gear usually applied on the Allis hoisting engines. This engine handles two 3-ton skips in balance by means of 1¼ in. ropes. One day in November in two shifts of 10 hours each, 3300 tons of ore were hoisted from this shaft. This makes 55 skips an hour.

At the Auburn and Norman delays were at times occasioned by large chunks of ore blocking the chutes underground. To obviate this they propose for the season of 1895 to put the raises at such a distance from the side of the drift and the chute that a level space may be formed on which the ore will pile up before it runs into the chute. This will give a sollar on which a man can stand and sledge up the masses that are too large to go through the chute.

Northwest of Virginia about four miles is the town of Mountain Iron. Here the Consolidated operates the Mountain Iron and Rathburn properties in one large open pit. This property is well located for open pit work. The ground slopes to the west and there is sufficient drop at the north and south ends for the entrance of cuts. The pit is about 1400 ft. north and south and 500 ft. east and west at the widest part. The stripping is 20 to 30 ft. The limits of the ore seem to have been reached at the north and east sides, but not to the south or the west. The first cut that was taken off, and which furnished the shipments for 1894, averaged about 20 ft. thick. A new thorough cut is coming in

from each end, which will give a 24-ft. slice over the property. This brings it down to water-level and will probably produce 700,000 tons more. After that the south approach must be lengthened very materially, or else slopes put in. Either of these are simply questions of relative cost.

Going west along the range to the town corner of 58–20, 58–21, 57–20 and 57–21, we come to the town of Hibbing. Here is a group of properties that promises to become the largest on the range. They are the Lake Superior, the Mahoning, the Sellars, the Sheridan, and a little west the Longyear.

The Mahoning, operated by the Mahoning Ore Company, while holding an option on many thousand acres, has confined its operation for the present to sections 1 and 2–57–21. Mine No. 1 covers the N. ½ N. ½ Sec. 1; Mine No. 2, W. ½ S.E. ¼, and E. ½ S.W. ¼, Sec. 2, and Mine No. 3, N. ½ N. ½ Sec. 2. Mine No. 3 has been test-pitted with some 56 small 4 by 6 ft. pits, 14 of these to a sixteenth section of 40-acre tract. They have been laid out very systematically, first in a row of four pits 330 ft. apart, then a row of three pits, staggered as regards the first row, then a row of four, and then a row of three, etc., rows being 330 ft. apart as well as the pits. Pits are sunk to ledge and if ore is encountered the pit is lined up with split cribbing, making it 4 by 6 ft. in the clear. The pit is now carried down in the ore of the same size till the foot is struck or else water encountered in such volume as to interfere with the sinking. In the latter case the sinking is stopped and a churn-drill hole put down. Sampling of the pits and drill holes has been carefully done, every 10 ft. in depth being determined by itself. The ore body on Mines No. 1 and 3 is about 2 miles long, ¼ mile wide, and averages 100 ft. thick; in addition to this it runs down on the next tier of forties south. All this, however, is not high grade merchantable ore. On Mine No. 2 there is about 40 acres of ore roughly covering the N.W. ¼, S.E. ¼, Sec. 2. The stripping varies from 15 to 100 ft. in thickness. Work this winter is being confined to stripping an area in the N.W. ¼, N.E. ¼, Sec. 2, by means of steam shovels. The cut comes in from the south over the Lake Superior property and begins to climb over the ore as the north sixteenth line or southern boundary of the Mahoning is reached. The material is carried half a mile south so as to waste it below any possible ore deposit. It is reported that the contract is for 300,000 yards of stripping at 30c. per yard. The exploratory work here has been very well done, the surface carefully surveyed, and topographical maps prepared, so that complete cross and longitudinal sections of the stripping and ore can be prepared. It has not been fully determined how all the ore shall be mined, but probably much of it will have to be done underground.

The Lake Superior covers the remainder of sections 1 and 2–57–21, the S.E. ¼, Sec. 36–38–21, and the S.W. ¼, Sec. 31–58–20. It is on this latter description that the work is now being done. Three shafts have been sunk along the south line, one of which is to be the pump shaft. This property has a great deal of water, but probably much of it will go to the Sellars next south, if they operate at the same time. The Sellars covers the N. ½ N.W. ¼, Sec. 6–57–20, and the town site of Hibbing is on the S. ½, N.W. ¼. The Sheridan is on 34–58–21 and the Longyear still further west.

It is probable that the Lake Superior and the Mahoning mines have at least

100,000,000 tons of ore. How much of it is Bessemer cannot now be determined. It is said that about 4,000,000 tons of good ore have been opened at the Longyear. Exploratory work is still going on west of this mine, and it promises to be a very important part of the range.

Test-pitting at Hibbing is nearly all done by contract with the men. The usual rate is $1.50 per ft., including timbering. Men make from $1.17 to $4 per day; three men work on a pit, one at the bottom and two on the windlass. One party of three men last summer sunk 30 ft. in ore in 3¼ days, or at the rate of 1 ft. per hour. The pit was 4 by 6 ft., untimbered, dirt hoisted by a windlass, depth not given. Churn-drilling can be contracted for at $2.25 per ft. everything furnished. All the wash-water is saved in barrels and consequently nearly all the sludge. Progress is made at the rate of about 6 ft. a shift. The holes have to be cased down or else they will cave.

Railroads of the Mesabi Range.—The Duluth & Iron Range road strikes off from the main line and runs west to Biwabik, McKinley, Eveleth and Virginia. This road docks its ore at Two Harbors, but the road runs on to Duluth. The Duluth, Missabe & Northern runs almost due north from Duluth, and at Iron Junction and Wolf spreads out into three branches, one going to Eveleth and Virginia, the second to Virginia, and the third to Hibbing. This road docks its ore at Duluth. Hibbing and the west end of the range will be accommodated by the Mississippi River Railroad, which was originally a standard-gauge logging road. It connects with the Duluth & Winnipeg road, which already has an ore dock at West Superior. This road came in to accommodate the Mahoning Ore Company, and puts that company in a rather better position than the other so-called independent mines. The Lake Superior Consolidated mines and the Duluth, Missabe & Northern Railway are really the same concern, while the Minnesota Iron Company practically owns the Duluth & Iron Range Railway. They have therefore no object in lowering rail freights.

Proportion of Bessemer Ore.—It is very difficult to tell with certainty how much of the Mesabi ore is Bessemer. It has been said that not over one-fifth of the ore was a strict Bessemer. This is probably too low, and from all the information so far available it seems probable that about one-third of the ore is Bessemer. It is well known that the Mountain Iron ore was rather irregular in phosphorus. No estimate can be ventured as to the absolute number of tons of ore opened up on the Mesabi. The amount is large, but all the data are not yet available.

LEAD.

By Frederick Hobart.

While the lead industry of the United States during 1894 suffered from the general depression there was not so great a decrease in the production as was generally supposed. The decline in the output, which is shown by our returns as collected from the producers and as given in the table below, amounted to less than 4% from 1893 and to about 12% from 1892, the year of the greatest production.

The following table shows the production of different kinds of lead in the United States from native and foreign ores for the five years from 1890 to 1894 inclusive; the statistics for the years prior to 1890 will be found in The Mineral Industry, Vols. I. and II.

PRODUCTION AND CONSUMPTION OF LEAD IN THE UNITED STATES.

(In short tons.)

Year.	Stock of Refined, Jan. 1.	Produced from U. S. Ores.				Smelt'd from Foreign Ores.	Total Smelt'd	Imported.		Total Supply.	Consumed	Exported, Bullion, Pigs or Bars.	Stock of Refined, Dec. 31.
		Desilverized.	Soft.	Antimonial.	Total.			In Bullion.	In Other Forms.				
1890	8,000	106,066	31,103	4,896	142,065	18,124	160,189	a9,975	.....	178,164	168,164	.....	10,000
1891	10,000	138,749	32,897	5,105	176,651	21,162	197,813	a4,615	.....	212,428	200,728	2,700	9,000
1892	9,000	145,217	31,655	5,805	182,677	26,734	209,411	a14,149	.....	232,560	214,186	12,874	5,500
1893	5,500	130,026	31,369	5,283	166,678	29,270	195,948	35,000	.....	236,443	195,457	35,000	5,991
1894	5,991	119,486	37,044	4,337	160,867	19,748	180,615	40,345	9,648	236,599	191,146	40,000	5,453

(a) Includes refined and other forms imported.

The decline in production in 1894, as shown by the table, was wholly in the silver-bearing lead from the Western mines, while the output of soft or non-argentiferous lead from the ores mined in Missouri, Kansas and Wisconsin showed a considerable increase. Again the lead smelted here from ores produced in foreign countries showed a large decrease, while that obtained by refining bullion showed a considerable increase. The amount of bullion imported was, indeed, the greatest in our history.

Undoubtedly the chief cause of the reduction in argentiferous lead was the low price of silver, which caused the closing of many mines in Colorado, Idaho and Montana. In Idaho especially, where labor strikes aggravated the situation, it was only the larger and better equipped mines which were able to withstand

the influence of the low prices of their lead and silver and continue work at a small profit. So unfavorable were the conditions for many of them that it is surprising that the decrease shown was only 10,545 tons, or 8.1%, in this class of metal.

The increase in soft lead was 5675 short tons, or 18%; a large part of this was from the lead districts of southeastern and southwestern Missouri and of Kansas, which continued actively at work notwithstanding the low prices and the depression of business. It must be remembered that the real output of these Missouri and Kansas mines is not measured by the production of soft lead, since a considerable quantity of the ore from those districts is taken to the refining works of the Middle States, where it is smelted with the Western "dry" ores.

Considering the general decrease in demand for raw materials of all kinds which prevailed during the greater part of 1894 and the special circumstances which affected the lead production, the result for the year must be considered not only satisfactory but very remarkable. Part of the result was due to the reaction which began in the later months of the year, but we must remember also that this reaction was but slightly felt at first and its full effect was not apparent until after the opening of the current year. It must be said, therefore, that the lead industry had comparatively little to complain of.

The effect of the demoralization in the silver market, which began with the closing of the Indian mints in June, 1893, had as a necessary result the closing of many of the silver-lead mines, as we have already noted. This decline in silver should have sustained the price of lead by lessening the production of the metal, but this did not occur to any considerable extent. The loss in this direction in the home output was made up by the amount of lead imported from Mexico in ore and bullion—chiefly the latter.

In the Western States, especially in Idaho, the rate of wages and the autocratic rule of the miners' unions have interfered so seriously with the working of silver-lead mines that the question has almost reach the point were the existence of the industry is in danger.

The steady increase in the output of Missouri and Kansas (non-argentiferous) lead through the lowest market is a satisfactory demonstration of our ability to compete with any country. Competent experts state that with large, well-designed works, Missouri and Kansas can produce with profit down to very near the cost of lead in Spain.

The heavy decrease of 9522 tons, or 32.5%, shown in the amount of lead smelted from foreign ores, is the direct result of the shortsighted and mistaken policy of imposing a heavy import duty on lead in ores. The result of this has been the establishment of an important smelting industry in Mexico, with American capital, and the heavy importations which should now come to the American smelters from Mexico will not be received, for the industry has become firmly established in that country. This is directly shown by the tables. The lead imported in ore in 1894 was only 19,748 tons, as against 29,270 tons in 1893 and 26,734 tons in 1892. On the other hand the lead imported in foreign bullion for refining increased from 14,149 tons in 1892 to 55,000 tons in 1893 and 40,345 tons in 1894. As the duty on lead in ore was relatively higher than on lead in bullion, a further inducement was offered to Mexican mine-owners to do their smelting at home, and the natural result was manifest.

Nearly all the lead in ore and most of that in bullion came to this country from Mexico. Some, however, is imported from Canada, and especially from the Kootenai region, where the silver-lead mines are being opened up to a considerable extent.

The imports of lead in pigs, bars and other forms amounted last year to 9648 tons; adding this to the lead imported in bullion we have a total of 49,993 tons which came into this country in metallic form. The lead imported in bullion nearly all came in bond to be refined, but a greater part of it was afterward entered for consumption and paid the duty.

The output of antimonial lead was 4337 tons and showed a decrease of 946 tons. This decrease resulted chiefly from the closing of Western mines and the diminution in output of the ores of those mines from which the antimonial lead is produced.

Lead in Missouri.—Dr. Charles R. Keyes, State Geologist, says that the second mineral in prominence produced by Missouri is lead. It is widely known over the State and has been mined on a commercial scale in 15 counties. It is known to occur in twice this number. The two principal ores mined are the sulphide and the carbonate; the former is the common galenite or galena, and the second cerussite or "dry-bone." The latter occurs at the surface, while the former is found at lower depths. The total product up to date has been about 750,000 tons, valued at over $60,000,000.

The principal producing districts are known as the southeastern, central and southwestern. In the southeast, where the lead is produced chiefly in St. Francois, Madison, Washington and Jefferson Counties, the ore is worked for lead alone. The ores of this region occur in the older Paleozoic limestones and have associated with them very little zinc. They are disseminated in small grains through solid limestone, and to distinguish between them and the concentrated ores of the southwest they are known as disseminated ores. They occur chiefly in particular layers of the limestones, and may hence be regarded as stratified.

In the central district there has been as yet little development in lead mining, but it is a region of which much may be expected in the future.

In the southwestern district the lead ores occur in connection with the zinc and are found associated in irregular deposits in crevices and cavities.

The most regular and steady progress made in 1894 was shown in the mines of the district having its center in St. Francois County. The ores there are of the disseminated class and are found in limestone. While the yield of the mines is of comparatively low grade, the deposits are large, and upon the whole much more reliable than the richer ores of the southwest, which occur largely in pockets or irregular masses. Moreover the working of the ores is comparatively simple. The present need of the district is improved machinery and operation on a larger scale, by which greater economy can be secured.

Lead in Idaho.—The chief silver-lead mines in the State are found in the Cœur d'Alêne and the Wood River districts. In the latter there have been comparatively few changes and the larger mines have generally kept at work. In the Cœur d'Alênes, however, the renewal of labor troubles caused the suspension of some mines and the irregular working of others, and materially diminished the output.

Lead Production and Consumption of the World.—The following table shows the production and consumption of lead in the principal countries of the world for the three years ending with 1893:

PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION OF LEAD IN THE CHIEF COUNTRIES OF THE WORLD. (*a*) (IN METRIC TONS.)

		Austria Hungary.	Belgium.	France.	Germany.	Great Britain. (*b*)	Italy.	Russia.	Spain.	Switzerland.	United States
1890	Production	11,251	9,617	4,578	104,958	49,795	17,768	836	117,953	.....	146,966
	Imports	3,471	35,985	67,418	13,477	161,187	2,484	17,824	.....	2,853	9,049
	Total	14,722	45,602	71,996	118,435	210,982	20,252	18,660	177,953	2,853	156,015
	Exports	1,075	27,370	9,653	33,981	51,200	518	.....	140,660	100	.....
	Consumption, pig lead.	13,647	18,232	62,343	84,454	159,782	19,734	18,660	37,293	2,753	156,015
	Imports of sheet lead, manufactures and lead products	353	.....	3,329	1,462	.....	297	3,414	.....	900	.....
	Exports of same	538	.....	5,674	20,796	21,194	1,607	.....	.....	.....	.....
	Grand total consump.	13,462	18,232	59,998	65,120	138,588	18,424	22,074	37,293	3,653	156,015
1891	Production	11,851	12,698	6,680	98,114	49,414	18,500	558	165,978	.....	180,800
	Imports	4,576	34,093	74,502	18,374	172,439	4,594	16,370	.....	1,867	1,737
	Total	16,427	46,791	81,182	116,488	221,853	23,094	16,928	165,978	1,867	182,537
	Exports	1,002	24,073	10,518	26,668	46,018	542	.....	140,000	129	.....
	Consumption, pig lead.	15,425	22,718	70,664	89,820	175,835	22,552	16,928	25,978	1,738	182,537
	Imports of sheet lead, manufactures and lead products	451	.....	3,644	1,224	.....	209	2,400	.....	933	.....
	Exports of same	545	.....	5,794	20,302	19,284	2,030	.....	.....	.....	.....
	Grand total consump.	15,331	22,718	68,514	70,742	156,551	20,731	19,328	25,978	2,671	182,537
1892	Production	12,209	10,146	6,655	100,710	44,935	22,000	600	160,000	.....	186,548
	Imports	7,375	31,054	73,720	18,477	185,707	2,166	18,646	.....	2,036	.....
	Total	19,584	41,200	80,375	119,187	230,642	24,166	19,246	160,000	2,036	186,548
	Exports	1,278	24,709	8,999	27,684	55,668	1,377	.....	153,859	114	.....
	Consumption, pig lead.	18,306	16,491	71,376	91,503	174,974	22,789	19,246	6,141	1,922	186,548
	Imports of sheet lead, manufactures and lead products	756	.....	2,569	1,113	.....	230	2,400	.....	984	.....
	Exports of same	596	.....	6,120	22,096	19,288	1,640	.....	.....	.....	.....
	Grand total consump.	18,466	16,491	67,825	70,520	155,686	21,379	21,646	6,141	2,906	186,548
1893	Production	12,364	12,006	8,119	97,855	38,186	19,898	.....	169,288	.....	177,764
	Imports	5,925	37,459	77,679	23,857	191,270	1,657	28,697	.....	2,011	31,752
	Total	18,289	49,465	85,798	121,712	229,456	21,555	28,697	169,288	2,011	209,516
	Exports	46	35,023	9,273	23,945	30,008	1,570	.....	.....	70	.....
	Consumption, pig lead.	18,243	14,442	76,525	97,767	199,448	19,985	.....	.....	1,941	209,516
	Imports of sheet lead, manufactures and lead products	1,102	.....	2,541	2,306	165	213	.....	.....	1,148	.....
	Exports of same	1,750	.....	5,715	25,677	19,645	2,182	.....	.....	19	.....
	Grand total consump.	17,595	14,442	73,351	74,396	179,968	18,016	.....	.....	3,070	.....

(*a*) The statistics of production in the above table are derived from official sources, as are also the imports and exports of the United States, Spain, and Belgium. The imports and exports of other countries are taken as reported by the *Metallgesellschaft*, Frankfurt-am-Main. In the statistics of production litharge is calculated as containing 80% lead.

(*b*) In the imports and exports for Great Britain the chemical products are not taken into consideration.

The figures of production in this table show a slight difference from those of the table given on next page, chiefly because the metal alone is considered and ores exported or imported are not taken into account. Great Britain is the largest consumer, owing to the quantity required in its varied manufacturing industries, though the quantities which are produced in the country are comparatively small, its supply is drawn very largely from Spain, which exports nearly all of its large output.

The demand for lead is steadily increasing, and it holds a place in industry inferior, perhaps, only to iron and copper in general importance.

The following table shows the lead production of the world for the five years ending with 1894:

LEAD PRODUCTION OF THE WORLD.
(In metric tons.)

Year.	Austria.	Belgium.	Canada.	France.	Germany	Greece.	Hungary	Italy.	Japan.
1890....	9,827	9,617	51	4,544	101,781	13,787	1,266	17,768	776
1991.....	9,397	12,698	267	6,680	95,615	14,528	2,173	18,500	803
1892.....	9,268	10,146	547	8,776	97,742	15,958	2,335	22,000	889
1893.....	7,212	12,006	968	8,119	74,659	14,534	2,514	19,898	1,115
1894.....	.....	.....	2,628	.....	100,753	13,955	.....	.....	.....

Year.	Mexico.	New South Wales.	Russia.	Spain.	Sweden.	United Kingdom.		United States.	Total.
						Foreign Ores.	Native Ores.		
1890.....	22,339	42,113	838	161,875	310	15,655	34,410	128,880	565,837
1891.....	30,186	56,482	558	160,418	299	16,681	32,733	160,347	618,365
1892.....	47,532	46,660	930	215,906	799	14,921	30,014	186,548	710,971
1893.....	60,525	59,780	.....	169,707	461	8,012	30,173	152,080	621,298
1894.....	.....	.....	.....	151,000	.....	.....	.....	145,906	.....

The table requires but little comment. It will be seen that Spain remains the largest producer of lead, although last year its total output was only about 5000 tons more than that of the United States. No other country compares in the extent of its production to these two; but Germany, Mexico and New South Wales are important producers. The German output, however, is not increasing, and has fallen off about 25% since 1890. In Mexico the production is increasing rapidly. The production of New South Wales is chiefly from the great silver-lead mines of the Barrier Range and reached its maximum in 1893. A diminution in production is probable, since at the Broken Hill mine, the principal producer, the high-grade ore deposits are largely worked out and the mine is each year depending more largely upon the low-grade ores. Spain and the United States together produce about 50% of the total output of the world, while 20% more comes from Mexico and New South Wales.

United Kingdom.—The following table shows the lead output of the United Kingdom for the four years ending with 1893:

PRODUCTION OF LEAD IN THE UNITED KINGDOM. (*a*)
(In long tons of 2240 lbs.)

Year.	North of England.	Derbyshire.	North Wales.	Mid-Wales, including Shropshire.	Isle of Man.	Scotland.	Ireland.	Elsewhere.	Total Long Tons.	Total Metric Tons.
1890...	13,149	3,020	5,074	4,851	4,530	2,881	5	80	33,590	34,140
1891...	11,531	3,157	4,909	4,434	4,926	3,198	7	43	32,205	32,733
1892...	9,786	2,836	5,232	3,589	4,930	3,064	31	72	29,540	30,014
1893...	11,173	3,236	4,828	1,388	4,734	2,665	41	1,643	29,698	30,173

(*a*) This table is compiled from statistics in the British blue books. The column "North of England" includes the production of Northumberland, Cumberland, Westmoreland, Durham, and Yorkshire; "North Wales" includes Flintshire and Denbighshire; while Cardiganshire, Montgomeryshire, and the English county of Shropshire are grouped under "Mid-Wales." In all the English statistics the production of lead is estimated from the output of dressed mineral reported by the mines, the amount of metal obtainable by smelting being reckoned at 95% of the dry assay value of the mineral.

The production is not increasing. The total for 1893 shows a decrease of 4,237 tons from 1890, owing to the partial exhaustion of the deposits and the competition of foreign metal.

The Range of Prices of Lead and Lead Products.

The accompanying interesting statement presents in tabular form the range of prices of white lead from 1783 to the present date; of red lead from 1796; of litharge from 1811, and of pig lead from 1812. There has been added also, covering the years from 1832 to date, the average invoice value of pig lead imported, the average rate of duty, the quantity of white and red lead imported and the average invoice value of those articles. The figures for this table, which we believe is more complete than any of the kind ever presented, were collected by Messrs. Wetherill & Brother of Philadelphia, and the whole statement forms a historical record of the greatest interest.

WHOLESALE PRICES PER 100 LBS. OF WHITE AND RED LEAD, LITHARGE AND PIG LEAD ALSO INVOICE VALUE OF IMPORTED LEAD, RATE OF UNITED STATES DUTY AND AVERAGE INVOICE VALUE OF WHITE AND RED LEAD IMPORTED SINCE 1783.

Year.	White Lead.		Red Lead for Potters.	Litharge.	Pig Lead, Domestic.	Average Invoice Value of Pig Lead Imported	Average Rate of Duty.	Amount of White and Red Lead Imported.	Average Invoice Value Per 100 lbs. of Red and White Lead Imported.
	Dry.	In Oil.						Pounds.	
1783..	$9.50	$12.50	.....	.....	.....	.....	.....	.....	.....
1784..	9.82	11.90	.....	.....	.....	.....	.....	.....	.....
1785..	11.90	11.67	.....	.....	.....	.....	.....	.....	.....
1786..	9.92	11.43	.....	.....	.....	.....	.....	.....	.....
1787..	9.82	11.43	.....	.....	.....	.....	.....	.....	.....
1788..	9.82	11.10	.....	.....	.....	.....	.....	.....	.....
1789..	10.27	11.10	.....	.....	.....	.....	.....	.....	.....
1790..	9.82	10.71	.....	.....	.....	.....	.....	.....	.....
1791..	9.82	10.71	.....	.....	.....	.....	.....	.....	.....
1792..	9.82	10.96	.....	.....	.....	.....	.....	.....	.....
1793..	9.82	11.16	.....	.....	.....	.....	.....	.....	.....
1794..	10.71	13.84	.....	.....	.....	.....	.....	.....	.....
1795..	11.90	13.39	.....	.....	.....	.....	.....	.....	.....
1796..	11.16	12.86	$6.70	.....	.....	.....	.....	.....	.....
1797..	11.30	13.32	.....	.....	.....	.....	.....	.....	.....
1798..	11.90	11.68	.....	.....	.....	.....	.....	.....	.....
1799..	12.50	14.29	.....	.....	.....	.....	.....	.....	.....
1800..	12.50	14.29	.....	.....	.....	.....	.....	.....	.....
1801..	14.29	14.29	.....	.....	.....	.....	.....	.....	.....
1802..	12.50	13.39	.....	.....	.....	.....	.....	.....	.....
1803..	12.50	14.29	.....	.....	.....	.....	.....	.....	.....
1804..	13.98	14.88	.....	.....	.....	.....	.....	.....	.....
1805..	13.98	15.00	10.71	.....	.....	.....	.....	.....	.....
1806..	14.73	16.27	11.16	.....	.....	.....	.....	.....	.....
1807..	16.74	16.91	11.25	.....	.....	.....	.....	.....	.....
1808..	16.96	17.32	11.61	.....	.....	.....	.....	.....	.....
1809..	16.29	17.28	12.50	.....	.....	.....	.....	.....	.....
1810..	14.29	16.97	11.61	.....	.....	.....	.....	.....	.....
1811..	14.29	16.97	9.38	$12.50	.....	.....	.....	.....	.....
1812..	17.86	21.43	10.27	14.29	$11.16	.....	.....	.....	.....
1813..	21.43	24.12	.....	.....	.....	.....	.....	.....	.....
1814..	20.54	21.88	20.54	.....	.....	.....	.....	.....	.....
1815..	21.43–35.71	21.43–35.71	14.29	14.29	17.86	.....	.....	.....	.....
1816..	10.71	14.29	8.48	9.82	.....	.....	.....	.....	.....
1817..	10.71	13.39	8.04	8.93	.....	.....	.....	.....	.....
1818..	10.71	12.50	7.59	9.82	.....	.....	.....	.....	.....
1819..	11.61	12.50	7.14	8.93	6.70	.....	.....	.....	.....
1820..	11.61	12.50	7.59	.....	6.36	.....	.....	.....	.....
1821..	10.71	12.50	8.48	8.93	6.63	.....	.....	.....	.....
1822..	10.71	12.50	8.04	8.93	6.35	.....	.....	.....	.....
1823..	10.71	12.50	7.59	7.59	5.36	.....	.....	.....	.....
1824..	10.71	11.61	7.59	.....	6.39	.....	.....	.....	.....
1825..	10.71	11.61	7.59	7.59	7.59	.....	.....	.....	.....
1826..	10.71	11.61	8.04	8.04	6.75	.....	.....	.....	.....
1827..	10.27	11.61	7.14	.....	6.14	.....	.....	.....	.....
1828..	9.82	11.61	7.14	.....	5.39	.....	.....	.....	.....
1829..	7.59	9.49	5.80	6.25	3.75	.....	.....	.....	.....
1830..	7.37	8.60	5.58	6.25	3.75	.....	.....	.....	.....
1831..	8.24–8.73	9.21	6.79	6.79	4.56–6.00	.....	.....	.....	.....
1832..	9.50	10.66	8.12	8.50	5.94	$2.33	$3.00	557,781	$5.52
1833..	9.50	10.66	8.35	8.75	5.91	2.66	3.00	625,069	5.77
1834..	9.35	10.16	8.37	8.50	5.12½	3.38	2.77	1,024,663	5.62
1835..	9.86	10.84	8.50	8.50	6.50	3.54	2.77	832,215	6.04
1836..	10.00	11.50	8.50	8.50	6.37½	3.84	2.55	968,105	6.85

Year.	White Lead.		Red Lead for Potters.	Litharge.	Pig Lead, Domestic.	Average Invoice Value of Pig Lead Imported	Average Rate of Duty.	Amount of White and Red Lead Imported.	Average Invoice Value Per 100 lbs. of Red and White Lead Imported.
	Dry.	In Oil.						Pounds.	
1837..	11.12	12.00	8.75	8.75	5.96	4.13	2.57	599,980	7.89
1838..	10.75	11.50	8.00	8.00	5.29	3.96	2.34	522,681	7.40
1839..	10.25	11.00	8.00	8.00	5.83	3.52	2.31	727,408	7.00
1840..	9.75	10.25	7.25	7.00	4.89	3.52	2.08	643,418	6.38
1841..	9.00	9.25	7.25	7.25	4.50	3.32	2.07	532,122	5.94
1842..	8.00	8.25	6.50	6.75	3.81	3.30	1.36–3.00	479,738	5.99
1843..	7.75	8.25	6.00	6.00	3.58	(*a*)	3.00	(*a*)	(*a*)
1844..	7.25	8.25	6.25	6.50	3.90	(*a*)	3.00	(*a*)	(*a*)
1845..	7.50	8.00	5.87	6.25	4.03	3.34	3.00	231,171	6.37
1846..	7.00	8.00	6.12	6.12	4.73	2.80	3.00	215,434	7.28
1847..	6.90	7.20	5.60	5.25	4.37	2.80	.56	298,387	5.10
1848..	6.18	6.83	5.62	5.62	4.26	3.18	.64	318,781	6.18
1849..	7.31	7.45	6.12	6.25	4.78	(*a*)	(*a*)	(*a*)	(*a*)
1850..	7.00	7.22	6.25	6.25	4.80	3.19½	.64	853,463	5.13
1851..	6.75	7.28	6.00	6.50	4.85	3.49	.70	1,105,852	4.76
1852..	6.31	7.06	6.00	6.25	4.80	3.42	.70	842,521	5.15
1853..	8.75	9.50	8.00	8.00	6.45	3.74	.70	1,224,068	5.64
1854..	8.50	9.25	8.25	8 25	6.57	4.39	.90	1,865,893	5.51
1855..	8.75	9.02	8.00	8.00	6.87	4.50	.90	2,319,099	5.81
1856..	8.37	9.09	8.37	8.50	6.59	4.51¼	.91	3,548,409	4.91
1857..	8.25	9.00	8.00	8.25	6.18	4.88⅛	.72	1,793,377	6.31
1858..	8.50	8.77	7.25	7.25	5.94	4.78½	.72	1,785,851	6.13
1859..	7.25	8.00	6.91⅔	6.91⅔	5.50	4.81	15%	3,555,564	6.08
1860..	7.25	8.00	6.79⅛	6.79⅛	5.65	4.95	15%	1,970,477	8.64
1861..	7.26⅞	8.06⅔	6.93¾	6.93¾	5.25	4.59	1.00	1,970,459	6.12
1862..	8.19¾	8.46⅞	8.21½	7.72½	6.10	4.12	1.50	635,511	5.96
1863..	10.43¾	12.16⅔	10.87½	10.35½	6.25	4.16	1.50	1,170,437	5.88
1864..	16.71⅞	16.81¼	16.18¾	16.18¾	7.10	4.35	2.00	1,903,053	5.39
1865..	15.58¼	15.87½	14.91⅔	14.75	6.60	4.37	2.00	3,064,778	3.35
1866..	13.40⅝	16.12½	12.30½	12.30½	6.90	4.08	2.00	7,477,732	5.91
1867..	12.73	14.34¼	11.49	11.50	6.50	4.33	2.00	7,440,831	6.43
1868..	12.18¾	13.60	10.85	10.85	6.50	4.24	2.00	9,110,824	6.04
1869..	13.27	12.00	10.66¼	10.66¼	6.45	4.11	2.00	9,455,449	5.72
1870..	9.63½	10.85	9.61½	9.61½	6.25	4.12	2.00	6,990,334	5.94
1871..	9.67½	11.30	9.00	9.00	6.10	4.00	2.00	9,356,134	5.79
1872..	9.40⅝	11.33⅛	8.81¼	9.21⅞	6.35	4.03	*b*2.00	7,033,499	5.91
1873..	10.61½	11.83⅛	8.86½	9.00	9.30	4.51	*b*2.00	7,809,868	6.39
1874..	10.50	11.25	8.29⅛	8.32¼	6.06	4.89	*b*2.00	5,268,361	6.80
1875..	10.00	10.83½	8.78⅛	8.75	5.95	4.79	*b*2.00	5,454,438	6.78
1876..	10.00	10.50	7.84½	8.75	6.05	4.89	2.00	3,241,951	6.93
1877..	9.30	9.81¼	7.77¾	7.18¾	5.45	4.60	2.00	3,031,444	6.72
1878..	7.50	8.08⅛	6.43¾	6.43¾	3.60	4.38	2.00	1,930,216	6.37
1879..	7.00	7.46	5.34⅜	5.34⅜	4.18	3.53	2.00	1,417,433	6.58
1880..	8.00	8.54¼	6.37	6.30	5.06	3.65	2.00	2,123,964	5.53
1881..	6.58⅛	7.03⅛	6.24	6.00	4.89	3.68	2.00	1,280,453	5.48
1882..	6.17	6.67	6.42	6.42	4.91	3.33	2.00	1,450,835	5.29
1883..	6.18	6.68	6.33	6.33	4.32	3.22	2.00	1,293,623	5.34
1884..	5.50	6.00	5.75	5.75	3.74	2.78	2.00	1,167,974	6.72
1885..	4.98	5.48	5.23	5.23	3.95	2.44	2.00	921,984	5.21
1886..	4.88	5.38	5.13	5.13	4.63	2.79	2.00	1,382,787	5.81
1887..	5.87	6.37	6.12	6.12	4.50	2.85	2.00	1,175,619	6.35
1888..	5.16	5.66	5.41	5.41	4.42	3.05	2.00	1,157,565	6.36
1889..	4.89	5.39	5.14	5.14	3.93	2.74	2.00	1,183,720	6.87
1890..	5.43	5.93	5.43	5.43	4.48	3.07	2.00	1,192,598	6.57
1891..	5.80	6.30	6.05	6.05	4.35	3.07	2.00	1,369,865	4.71
1892..	6.50	6.75	6.75	6.75	4.05	3.34	2.00	1,546,322	4.53
1893..	5.75	6.38	6.38	6.38	3.69	4.06	2.00	1,829,380	4.08

(*a*) Data not at hand. (*b*) Less 10%.

During the years from 1832 to 1863 the importations evidently varied directly with the demand. They increased steadily with the growth of the country and the amount of material which would probably be required. The fluctuation in the opposite direction marked the panic years—such as 1857 and 1858—when business was disordered and consumption of all the materials comparatively light. The war period again was marked by a heavy decrease. From 1864 to 1871 the importations of white and red lead showed a remarkable growth. They reached their maximum point in 1869 and very nearly touched that maximum again in 1871; but from 1872 onward they showed a rapid and almost uninterrupted decline, doubtless due to a corresponding growth in the domestic production. From 1885 to 1893 the fluctuations were not large,

Prices of Lead 1890–1894.

The following table shows the average price of lead in New York for each month of the five years from 1890 to 1894, inclusive. For the years prior to 1890 statistics will be found in The Mineral Industry, Vols. I. and II. The quotations are for spot lead in carload lots or over.

AVERAGE MONTHLY PRICES OF LEAD IN NEW YORK, IN CENTS PER POUND. (*a*)

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1890..	3.86	3.85	3.95	4.05	4.20	4.42	4.62	4.60	5.11	5.87	5.02	4.24	4.48
1891..	4.38	4.31	4.35	4.25	4.28	4.48	4.42	4.42	4.52	4.39	4.12	4.25	4.35
1892..	4.20	4.12	4.21	4.15	4.22	4.16	4.13	4.11	4.11	4.02	3.84	3.80	4.09
1893..	3.87	4.22	3.96	4.08	3.89	3.77	3.58	3.41	3.80	3.51	3.41	3.27	3.73
1894..	3.19	3.31	3.37	3.43	3.39	3.31	3.50	3.41	3.17	3.12	3.14	3.10	3.29

(*a*) From the market reports of the *Engineering and Mining Journal*.

The prices in the London market for English and Spanish lead are given below. The quotations for Spanish lead are usually from 2s. 6d. to 3s. 6d. below those of the English metal.

AVERAGE MONTHLY PRICE OF ENGLISH PIG LEAD IN LONDON, PER TON OF 2000 LBS. (*b*)

Year.	Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1890.....	14 2 9	12 17 6	12 13 1	12 15 11	13 1 9	13 7 6	13 1 10	13 2 9	13 16 3	14 14 0	13 19 4	13 1 3	13 7 10
1891.....	12 19 9	12 12 6	12 13 1	12 13 1	12 13 3	12 16 3	12 12 3	12 7 2	12 7 8	12 4 3	11 16 10	11 10 6	12 8 10
1892.....	11 4 8	11 0 7	11 2 6	10 19 3	10 16 7	10 19 4	10 15 0	10 11 3	10 8 6	10 13 1	10 8 5	10 1 10	10 15 1
1893.....	10 0 10	9 13 3	10 2 0	10 2 6	10 6 3	9 10 6	10 2 6	10 0 6	9 19 4	9 14 6	9 16 9	9 13 9	9 18 6
1894.....	9 10 0	9 7 6	9 8 3	9 8 1	9 3 9	9 4 1	9 11 11	9 18 9	10 1 3	10 0 8	9 17 9	9 13 9	9 12 1

(*b*) From the Metal Price Current of Vivian, Younger & Bond, London. The prices are f. o. b., with a discount of 2½%.

AVERAGE MONTHLY PRICE OF SPANISH LEAD IN LONDON, PER TON OF 2000 LBS. (*c*)

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1890..	13 11 9	12 14 1	12 10 0	12 12 6	12 18 4	13 4 10	12 17 6	12 18 4	13 12 1	14 7 9	13 11 3	12 16 10	13 2 11
1891 .	12 14 4	12 9 8	12 9 6	12 10 0	12 8 9	12 13 11	12 7 6	12 2 9	12 4 3	12 0 7	11 12 2	11 6 9	12 5 0
1892..	10 18 1	10 13 11	10 17 4	10 12 4	10 11 9	10 13 5	10 19 3	10 5 11	10 3 4	10 7 0	10 1 10	9 19 0	10 9 5
1893..	9 15 11	9 10 9	9 16 3	9 14 0	9 11 3	9 7 3	10 0 9	9 19 6	9 15 7	9 12 0	9 14 8	9 10 0	9 14 0
1894..	9 8 1½	9 5 7½	9 5 0	9 3 9	9 1 10½	9 2 6	9 9 6½	9 7 ½	9 17 6	9 17 6	9 14 2	9 11 3	9 8 7

(*c*) For years previous to 1894, from British blue books. For the year 1894, compiled from Vivian, Younger & Bond's Metal Price Current. The prices are for Spanish, soft, without silver, ex ship, 2½% discount for cash.

The quotation of lead in the various important markets of Germany are given below:

AVERAGE YEARLY PRICE OF LEAD IN THE PRINCIPAL MARKETS OF GERMANY. (*d*)
(In marks per 100 kilos.)

Year.	Berlin, Saxonia, Tarnowitz, Refined Hartz.	Cologne, Rhenish, Soft, Double Refined, Rhenish Brands 3 Months.	Frankfurt-am-Main, Rhenish Double Refined in Pigs at Works.	Halberstadt.		Hamburg, Hartz, Soft Pig Lead, Double Refined.
				Refined Hartz, Soft, 3 Months at Works.	Ref'd Silesian, Soft, 3 Months at Works.	
1890.....	28.10	27.47	26.83	25.91	25.65	29.05
1891.	26.23	25.56	25.34	24.74	24.72	27.15
1892.....	23.13	22.05	21.73	21.02	20.98	23.16
1893.....	21.25	20.46	20.10	19.52	19.70	21.73
1894.....	20.80	19.55	19.20	19.13	19.28	21.02

(*d*) From *Vierteljahrshefte zur Statistik des Deutschen Reiches*.

The New York Lead Market in 1894.

The lead industry had to suffer greatly throughout the year from all sorts of adverse influences. At the very beginning of the year legislation brought prices down to an unnaturally low level, from which they only recovered on a few occasions, which were, however, of short duration. With the lower silver values which were again established during different periods of the year, the Western producers had very hard times indeed, and only a few favored ones were able to make both ends meet. Early in January reports came to hand to the effect that the Senate committee intended to change the Wilson bill in such a way as to cut the existing duties in halves, and during the long period that the tariff bill was under discussion in the Senate, this threat alone was sufficient. Although the elections of 1892 were fought out on the principle of free raw material, the new tariff bill showed very little of this sound principle, but rather the contrary, and lead is one of the instances which can be cited as an example.

Lead ores are now taxed with a duty of ¾c. per lb. of material, and, as lead ores which are imported from foreign countries very seldom carry more than from 30% to 40% of lead, it will be seen that they are taxed twice or thrice as heavily as pig lead or lead bullion.

A distinction is made between lead ore and silver ore carrying lead, and in the latter case the lead contents are subject to a duty of ¾c. per lb. on the lead contained therein; but even this duty is comparatively too high with the duty of 1c. on pig lead, if the losses in smelting, extra freight, etc., are taken into consideration. If the legislative body had intended to drive the industry more and more into Mexico it could not have adopted better methods.

Manufacturers of white lead, sheet lead and pipes are hardly much better off than smelters or refiners, being protected only by a duty of 1½c., and the very moment when pig lead can be advantageously imported from Europe to this country European manufacturers will be able to bring over the manufactured goods to the detriment of our home industries. In consequence of this it is not at all astonishing that the production of silver-lead ores shows a very decided falling off, and the probability is that this will not change materially during the present year. The only increase in production which we are able to report is in Missouri, where straight lead ores are mined, and where great economies have been inaugurated during the last few years in the smelting and refining. Although this industry is also seriously interfered with by the lower prices, operations can still be conducted at a moderate profit, and the probabilities are that the output will still further increase.

In consequence of the continual depression, owing to which all industries had to suffer more or less, the consumption of lead during the past year was not as large as during the few preceding years. At any rate, the falling off in production was so great that a certain quantity of pig lead had to be imported, and in all nearly 10,000 tons have been received from Europe; besides, certain quantities of the Mexican bullion, which is being refined in this country, were retained here after the duty was paid, and as matters stand now the probability is that henceforth a larger proportion will be used in the same way. Necessarily, each pound of lead so retained here replaces a pound of Western lead.

The Eastern markets being thus to a certain extent cut off for Western

producers, and the Middle States not being able to take the entire quantity, it will in future be a close fight between the two products, from which the price of the metal must suffer.

By a ruling of the Treasury 10% of the bullion received from Mexico and refined in this country could heretofore be retained here as exempt lead, less the losses in refining, which range from 2½% to 4%; or, in other words, a quantity of about 3000 tons of lead was kept for home consumption, while the balance, or nearly all of it, was exported. This ruling was changed early in December, and the owners of the Mexican bullion at once found it to their advantage to keep all their lead here, and this had an immediate adverse effect on prices, which thus reached a lower level than ever before in the history of this metal in this country.

In January prices opened at 3.20c., but the market shortly grew firmer, and by the middle of February 3.40c. was reached, at which time there were rumors afloat that the duty on lead would be reduced, and this was sufficient to at once bring the market down to 3.25c. This lower range of prices made producers reluctant sellers, and accentuated a slight firmness, but it was not until the end of March that, with the beginning of spring, a larger demand set in, and 3.50c. was touched, and for two months the quotation from 3.40c. to 3.50c. could be fairly well maintained.

Early in June the Senate decided to reduce the duty to 1c., which strengthened the foreign markets and lowered our own, and prices quickly fell to 3.25c., at which figure considerable transactions took place; in fact, so large that a natural reaction upward set in, and prices advanced to 3.35c., which value was maintained until the end of July. At this time it appeared very doubtful whether the tariff bill would become a law, and naturally this at once affected lead most materially. Prices went up to 3.60c. with hardly any sellers thereat, and if the tariff bill had been defeated, the old quotation of 4c. would have been reached in a very short time. So all eyes were centered on Washington, as naturally the moment the duty was reduced foreign lead could be laid down here at about 3.25c.

Thus during the month of August when a compromise between the two houses seemed possible, prices eased off, and when the bill became a law, prices at once dropped down to the importation point—3.20c.@3.25c. In the meantime some importations of foreign lead had been made, which, it was understood, would be used in case the tariff bill did not become a law; if it did they would be again exported and drawbacks collected; but as this lead was purchased at the lowest possible price it became available for the home market at 1c. duty. This depressed the market, which then came down to 3.12½c.@3.15c., where it remained with some slight variations until the beginning of December, when the ruling hereinbefore mentioned became a law, and prices dropped down to 3.02½c. @3.05c., at which they closed. We may fairly expect a better consumption during 1895, but no hopes of a material rise can be entertained, as the foreign material will always be a menace.

The London Lead Market in 1894.

For the first half of the year 1894 this market was very dull, and the values ruling were decidedly low, touching during May and June the lowest price on record; but the year closed a half-crown better than it opened.

In January the market opened at £9 8s. 9d. for soft foreign lead, and £9 12s. 6d. for English. There was a little American lead offering, and with one prominent operator endeavoring to depress the market, the value of soft foreign declined to £9 5s. An improvement of 1s. 3d. per ton was followed in February by a relapse to £9 3s. 9d., whereupon a slight demand arose, and sellers being less in evidence, we had a recovery to £9 7s. 6d. At this level the English smelters evinced more disposition to sell, and the few orders in the market having been filled, lead again moved downward. All the chief lead-consuming industries were buying only in small quantities, so that £9 3s. 9d. was again reached at the end of March, and this remained the value until toward the middle of April. Consumers were tempted into taking fair quantities at this low level and the consequence was a recovery to £9 6s. 3d. The slight spurt having spent itself, the market collapsed and £9 1s. 3d. was recorded at the close, while during the whole of May the value did not rise about £9@£9 2s. 6d., the lowest prices ever recorded.

In June after £9 1s. 3d. had again been accepted, a somewhat better aspect of affairs as regards manufacture and consumption rather stiffened makers' ideas and improved the market, which closed at £9 3s. 9d. In July there was a more marked improvement, £9 6s. 3d. and £9 7s. 6d. being done in the first week. There was very little lead offered, and America, in particular, was not in the market, while considerable quantities of Spanish lead were going to France in anticipation of increased duties in that country. The tone of the market was thus rendered decidedly strong; £9 12s. 6d. for soft foreign and £9 15s. for English were eventually marked. Before the month closed, however, the market was discouraged by fresh offers of American lead and by the antagonism of a large operator, so that £9 8s. 9d. was taken at the close.

In August a strong impetus to demand was imparted by the reduction of the duty into the United States and the value rose quickly to £10 2s. 6d. From this point there was a steady decline until near the close of the year. While £9 16s. 3d. was touched in September, in October sheet lead was in strong demand for the East, to which large shipments were made, and the market ruled steady at £9 18s. 9d.@£9 16s. 3d. In November £9 17s. 6d., £9 15s., and £9 12s. 6d. were the successive stages of the decline, and £9 10s. early in December, the closing values being £9 11s. 3d. for soft foreign and £9 13s. 9d. for English lead, while the tendency is toward a stronger market in view of decreased production.

The Board of Trade returns give the total imports and exports of lead in the United Kingdom as below, in tons of 2240 lbs.:

Year.	Imports.	Exports.	Net Imports.
	Tons.	Tons.	Tons.
1894.....	161,372	47,146	114,226
1893.....	188,249	48,871	139,378
1892..	182,782	58,162	124,620

The Distribution of Silver in Lead Bullion, and the Different Methods of Sampling.

By A. Raht.

The above is the title of an article which appeared in the issues of Sept. 28 and Oct. 5, 1894, of the *Berg- und Hüttenmännische Zeitung;* the data given in this article by Mr. R. Rosenlecher are so much at variance with those obtained in sampling lead bullion in the United States that a short description of our American views and methods seems in order.

Out of a great number of experiments which I have made at different times on the distribution of the silver in lead bullion, Figs. 1 to 5 illustrate one in which the differences of silver contents in different parts of the bar are most striking; Figs. 1, 2, 3 and 4 are sections taken on the lines correspondingly numbered in Fig. 5. This bullion was red-hot when it was cast, which no doubt accounts for the large differences; the metal entered the mold near section 2, in which is shown the cavity left by the contraction of the metal while congealing. Other tests made under my supervision, as well as a great many made by others, which have come to my knowledge, all tell the same story; they all show that the lowest silver contents are in that part of the bar in which the metal congealed last. This is contrary to the statement of Mr. Rosenlecher, who claims to have always found the richest spot under the lowest place of the sunken surface of the bar; it seems, indeed, almost as if he had been led into this error by accepting the result of one faulty sample or assay.

For my own part I have no theory to offer in explanation of the phenomenon referred to, unless it is simply that the metal having the higher melting point would naturally congeal first, while Mr. Rosenlecher evidently takes it for granted that this separation must take place entirely according to the principle governing the Pattinson process, and, I am afraid, strained some of his statements so as to conform to his theory. It seems to me that even his own figures do not support that theory.

In Fig. 6 are shown the assays of a section of a bullion bar which was cooled by a spray of water before the metal solidified, while Fig. 7 shows a similar section of a bar, which was cast at the same time and of the same metal, left to cool without artificial means; both of these show plainly again that the metal which solidifies first is the highest in silver.

As most of the silver-lead bullion in this country is produced in the Western States and Territories and then sold to refineries situated in the eastern part of the United States the correct sampling of bullion is of the greatest importance, and through the lively competition among the different refiners more exact methods have necessarily been developed in America than in Germany, where but little lead bullion is sold, and that mostly to refineries owned or controlled by the government, whose returns are accepted as satisfactory without questioning too closely into the method of sampling.

Although there are several methods in use in the United States, I think the following, or slight modifications of it, is the most generally accepted: Five bars of bullion are placed side by side, and by means of a sort of a belt-punch, which is hammered halfway into each bar, cylindrical pieces of metal, of say

Fig. 1

170.25 4.45	165.57 4.23	164.55 4.15	161.81 4.09	160.62 3.88	162.31 4.09	164.65 4.15	165.17 4.23	168.65 4.45
	167.0 4.30	164.82 4.18	161.34 4.06	160.28 3.92	161.54 4.06	166.02 4.18	167.6 4.30	
	168.59 4.31	167.73 4.27	164.61 4.19	163.28 4.02	164.41 4.19	167.23 4.27	169.89 4.31	
	167.49 4.31	167.27 4.33	163.72 4.18	163.72 4.05	163.82 4.18	168.17 4.33	167.89 4.31	
170.41 4.39	167.38 4.32	165.92 4.28	166.22 4.18	166.92 4.28	166.08 4.32	168.41 4.39		
	167.39 4.31	166.12 4.28	167.68 4.22	166.02 4.28	166.69 4.31			
	166.58 4.32	167.56 4.34	169.69 4.31	167.46 4.34	167.08 4.32			

Sawdust average { 4.23 Au / 167.8 Ag } OZS. per ton

Fig. 2

168.53 4.47	167.19 4.31	164.61 4.19	150.73 3.65	142.44 3.66	149.85 3.65	165.31 4.19	167.19 4.31	168.93 4.47
	171.33 4.37	168.05 4.25	131.60 3.00	110.33 2.67	X Cupelo broken	168.35 4.25	171.83 4.37	
	168.80 4.40	X	150.08 3.02	147.6 3.40	139.08 3.02	167.94 4.26	168.5 4.40	
	174.5 Au & Ag	168.85 4.35	164.31 4.09	152.66 3.64	163.81 4.09	169.55 4.35	174.0 Au & Ag	
	171.63 4.57	169.3 4.40	166.61 4.19	158.79 3.91	165.31 4.19	169.1 4.40	170.88 4.57	
		170.35 4.45	164.66 4.24	162.8 4.10	163.86 4.24	170.75 4.45		
		170.09 4.51	170.61 4.49	171.1 4.40	169.51 4.49	170.9 4.51		

Sawdust average { 4.13 Au / 163.4 Ag } OZS. per ton

Fig. 3

168.9 4.40	167.76 4.34	167.09 4.31	165.15 4.15	159.83 4.07	165.15 4.15	167.29 4.31	168.06 4.34	167.1 4.40
	X	165.76 4.34	166.69 4.21	160.05 4.05	166.09 4.21	171.06 4.34	X	
	167.13 4.37	169.06 4.34	X	161.73 4.06	167.58 4.12	168.76 4.34	169.83 4.37	
	168.84 4.36	168.43 4.37	166.27 4.33	161.14 4.06	166.47 4.33	170.03 4.37	170.04 4.36	
168.06 4.34	169.62 4.26	168.49 4.31	167.0 4.20	166.99 4.31	X	171.06 4.34		
	168.75 4.35	168.46 4.34	168.4 4.40	169.06 4.34	168.75 4.35			
	166.51 4.19	170.14 4.36	168.18 4.22	169.34 4.36	165.91 4.19			

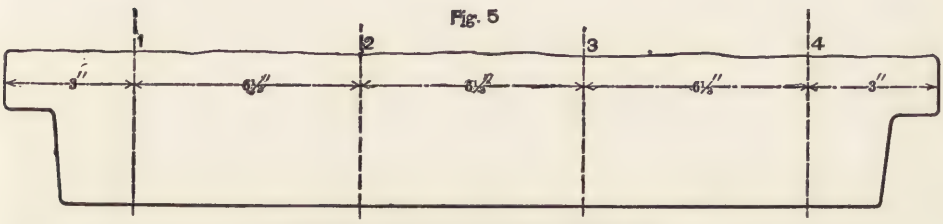
Sawdust average { 4.27 Au / 166.8 Ag } OZS. per ton.

Fig. 4

165.8 4.40	164.85 4.35	164.99 4.21	162.19 4.11	159.28 3.92	162.69 4.11	164.39 4.21	164.13 4.35	168.3 4.40
	167.06 4.24	166.51 4.19	162.67 4.03	159.76 3.94	162.77 4.03	165.21 4.19	166.86 4.24	
	168.26 4.34	167.85 4.35	165.42 4.18	163.15 3.95	165.92 4.18	167.95 4.35	167.86 4.34	
	170.83 4.27	167.82 4.28	165.97 4.23	165.59 4.01	166.07 4.23	167.62 4.28	168.63 4.27	
	169.23 4.27	168.52 4.28	166.96 4.24	165.08 4.12	167.56 4.24	168.32 4.28	168.83 4.27	
		167.74 4.36	167.77 4.33	166.16 4.24	168.57 4.33	167.24 4.36		
		168.52 4.38	168.42 4.38	169.19 4.31	169.52 4.38	166.12 4.38		

Sawdust average { 4.24 Au / 166.8 Ag } OZS. per ton.

Fig. 5



SECTIONS OF BAR OF LEAD BULLION.

⅛-in. diameter, are taken out; as shown in Fig. 8, the position of the punch in each bar is changed as to length and width of the bars; it is best to use a templet made of sheet-iron to indicate the exact spot where each hole is to be punched; this templet is made to fit over the edges of the bar, and is provided with little spring punches, which, being tapped with a hammer, mark the spot to be punched on the bullion bar; after the bars are punched and the samples obtained from the top they are turned bottom side up and punched again in a similar way, so that one sample chip is obtained from the top and one from the bottom of each bar. Usually one carload of about 20 tons is sampled as one lot; all the chips from this lot, weighing about 8 to 10 lbs., are then melted together in a graphite crucible at a dark-red heat, and after being well stirred the metal is poured into a mold, which is of such shape that the sample bar produced

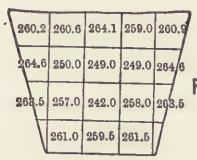


Fig. 6

Average 258.2, OZS silver per ton.

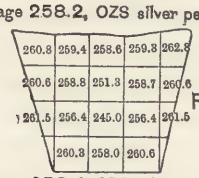


Fig. 7

Average 258.4, OZS silver per ton

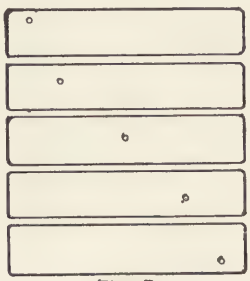


Fig. 8

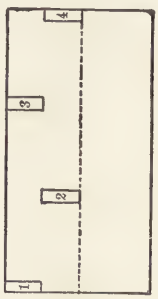


Fig. 9

measures about 10 by 5 by ½ in. This bar is cut in two lengthways; one half is reserved for umpire assay, while the other half is cut as shown in Fig. 9, to get the four samples of one-half assay-ton each, which are assayed; the average weight of the four resulting silver buttons is taken as the correct silver contents of the lot. In order to show the difference of contents between these four cuts I give here the average of a great number of assays:

	Silver per Ton.	Relation to Average.
Cut No. 1	227.06 oz.	+ 0.68 oz.
Cut No. 2	225.46 oz.	— 0.92 oz.
Cut No. 3	225.90 oz.	— 0.48 oz.
Cut No. 4	227.10 oz.	+ 0.72 oz.

The variations in the different cuts would appear much larger if the molds used had been heated, perhaps by a previous cast in the same mold, or if the bullion had been unduly hot in casting or from any other cause which would retard the congealing. All this demonstrates again that the metal congealing first carries the highest, and that which remains liquid longest the lowest, silver contents.

It is obvious that the method of sampling described, although in nearly general use, is subject to a number of serious objections, of which I will only point out the following: On account of the uneven distribution of the silver in the bullion bar it is evident that the correct location of the punch-holes is tedious and difficult, as the distribution changes with the manner in which the bars are cast; then

again if the punch is not driven quite vertically into the bar it would cause a different result, as I have often had occasion to notice, since the workmen are inclined to drive the punch slanting toward the middle of the bar. The melting operation, even if performed with the greatest care, is objectionable, as a slight oxidation of the lead can hardly be avoided; and again the uneven distribution of the silver in the sample bar is liable to cause errors, especially in impure bullion, and more especially if the impurity should be copper in any considerable quantity.

It is but natural, therefore, that better methods of sampling should be sought, which would do away with the objections pointed out above. One of the smelting works in Colorado has lately adopted the saw sample with apparently satisfactory results and quick work. The sampling is not done, however, in the manner proposed by Mr. Rosenlecher, who picks out certain bars which show the sunken surface exactly as they should, according to his preconceived theory, and these he saws "well into the center" with a hand-saw at such places which best suit his pet theory, and which in my opinion would most likely give the lowest result in silver; certainly no Western smelting man would sell his bullion subject to such unfair sampling.

The saw sample at the works mentioned above is taken in the following manner: A circular saw driven by steam power is set in a table arranged with a slide and gauge in such a manner as to let the saw cut just half of the area of the cross-section of each bar; the cut of the first bar is taken at one-sixth of the bar-length from the end, the second bar is cut at a point two-sixths of the length from the end, and so on; in varying the distance from the end of the different bars the resulting sawdust from the whole 20-ton lot is expected to represent a fair average. This sample weighs about 70 lbs. and is thoroughly mixed and then quartered down like an ore sample; from this quantities of half assay-ton are taken for assaying without any previous remelting. The objection to this method is that one cannot be at all sure that the sawdust obtained from cuts at fixed distances from the end of the bars really does represent a fair average, as even if we admit that this might be the case in a certain bullion lot, it could not be correct with another lot cast under different conditions or differing from the first lot in the amount or quality of impurities, since any of these would cause a different distribution of the silver in the bar, and thus vitiate the sample. From all this it appears that all methods of sampling which treat the bullion in the solid form must necessarily be more or less unreliable. This leads to the conclusion that the sampling should be done while the bullion is in the molten state.

The taking of dip-samples out of the molten metal was proposed by one of the Eastern refiners several years ago, and it came quite recently into use at one of the smelting works in Colorado with very satisfactory results, the method adopted being as follows: After melting the bullion bars down in a kettle holding about 20 tons, the coppery dross is skimmed off and sent back to the blast furnace to be smelted over; with this one of the worst sources of error in sampling is removed. The bullion is then thoroughly stirred, say for five minutes, and while this is still going on a number of samples are taken by means of a small ladle holding approximately one-half assay-ton of metal; it is important

that this ladle should be at least as hot as the bullion, so that none of the metal would stick to its surface, otherwise the samples would be too low in silver. The samples thus obtained are taken direct for assaying, without any trimming or clipping. Instead of trimming the sample down to the exact weight of half assay-ton, the exact weight of each sample is ascertained, whatever it may be, and from the resulting silver button the contents are figured. Care is taken, however, in the selection of the samples for assaying out of the great number originally taken, that these should be somewhere near the same weight, so that when they are cupelled side by side they would finish about the same time. It will be seen that all the objections to punch sampling named above are met in this method. Still, another one might be raised against it, which is the uncertainty whether the mixture was thorough. I must say that this does not appear to carry much weight, but it can be overcome by taking samples at regular intervals out of the stream of metal running from the kettle into the molds. These samples would have to be remelted in a graphite crucible and out of this again one-half assay-ton samples taken, which are then treated as above. This method, of course, brings in again the objection to the remelting. There cannot be the least doubt that either of these two dip-samples would be nearly absolutely correct, but they can be carried on only at the works of the seller of the bullion, as it would be next to impossible to obtain a correct sample from the dross skimmings. It is to be hoped that the dip sample will be generally introduced wherever practicable, and so do away with the annoying sample and assay differences between the bullion producer and refiner.

In connection with these assay differences the following may be of interest. For some time past I had noticed that bullion samples assayed in the East average lower than similar samples assayed under apparently the same conditions in the West. At first I thought that this might be caused by the fact that the refiner's assayer would perhaps not be quite so anxious to cupel at the lowest possible heat as the assayer of the Western bullion-producer. I found, however, that several Western assayers, when sent East to verify their results obtained in the West, could not reach their Western average results by fully 0.3 oz. silver per ton on several hundred assays on different kinds and grades of bullion. I began then to think that something in our Western climate or in the altitude must be the cause of these differences. This may at first seem almost ridiculous, but when I learned that the proper cupelling of one-half assay-ton of bullion occupies about 19 minutes in the East, at sea level, while it takes nearly 22 minutes to do the same in the West, at say 4500 ft. altitude, it began to look more reasonable. This view is strengthened by the fact that this time is almost exactly in inverse proportion to the atmospheric density at the different altitudes—26 and 30 in. barometric pressure.

Recent Improvements in the Treatment of Argentiferous Lead Ores.

By H. O. Hofman.

In the following pages will be found a summary of all that has appeared of any importance upon the subject during the past year, being practically a continuation from Volume II. of The Mineral Industry; also of all the patents as published in the *Engineering and Mining Journal*, and in addition various items privately obtained, but published here with the knowledge of those who have furnished them. The headings have been retained in the same order as before, and the same abbreviations used, as follows:

B. & H. Ztg., Berg- und Hüttenmännische Zeitung.
Ch. C., Chemisches Centralblatt.
Chem. News, Chemical News.
Ch. Ztg., Chemiker Zeitung.
Coll. Eng., Colliery Engineer.
E. & M. J., Engineering and Mining Journal.
Eng. Mag., Engineering Magazine.
J. Am. Chem. S'y, Journal of the American Chemical Society.
J. Chem. S'y, Journal of the Chemical Society, London.
J. S'y Chem. I., Journal of the Society of Chemical Industry.
J. I. & St. I., Journal of the Iron and Steel Institute.
M. I., Mineral Industry.
M. S. P., Mining and Scientific Press.
O. J., Berg- und Hüttenmännisches Jahrbuch der K. K. Bergakademieen, etc.
O. Z., Oesterreichische Zeitschrift für Berg- und Hüttenwesen.
Pr. Z., Zeitschrift für Berg-, Hütten-und Salinen-Wesen in Preussen.
Proc. Eng. S'y West. Penn., Proceedings of the Engineers' Society of Western Pennsylvania.
Proc. Inst. Civ. Eng., Proceedings of the Institute of Civil Engineers.
S. M. Q., Columbia School of Mines Quarterly.
St. & E., Stahl und Eisen.
Th. I. Z., Thonindustrie Zeitung.
Tr. A. I. M. E., Transactions of the American Institute of Mining Engineers.
Z. Anorg. Ch., Zeitschrift für Anorganische Chemie.
Z. Angew. Ch., Zeitschrift für Angewandte Chemie.
Z. E. & E., Zeitschrift für Electrotechnik und Electrochemie.
Z. Phys. Ch., Zeitschrift für Physikalische Chemie.

INTRODUCTORY.

History.—Winslow* publishes a historical sketch of lead and zinc from his report on the ore deposits of lead and zinc of Missouri to the State Geological Survey.

Alloys of Lead.—Wiesengrund publishes his studies on tin-lead alloys in pamphlet form.† He examined alloys ranging from 1 Pb : 12 Sn to 12 Pb : 1 Sn for the conditions of their solidification, and found that the alloy Pb Sn_3 (36.93% Pb, 63.07% Sn), which he considers to be a chemical compound and calls "chemical alloy," solidifies at 178.25° C. and melts at 183° C. These points are invariable unless the composition is altered. An addition of lead raises the point of solidification, one of tin lowers it; an addition of either lead or tin raises the melting point. With all the other alloys the melting point is slightly raised for each successive melting. The point of solidification, if higher than that of the chemical alloy, becomes lower with each repetition, and if lower rises, thus in both cases approaching nearer to that of the chemical alloy with each successive operation. The chemical alloy shows a lower specific gravity than would be expected from the average of that of its two components.

Sampling.—Williams describes,‡ in a paper to be continued, the taking of samples in the mine, and discusses with illustrations the sampling of broken material under the heads of hand sampling, mechanical sampling, and combined hand and mechanical sampling. He completes the first head in the first

* *E. & M. J.*, Nov. 17, 24, 1894. † Rostock, 1894; *B. & H. Ztg.*, 1894, p. 305. ‡ *Coll. Eng.*, XV., p. 1.

paper, treating of the grab sample and fractional selection, channeling, quartering and spilt-shoveling.

Clarkson discusses the sampling of iron ores in the *J. I. & St. I.*, 1893, II., p. 131. He takes up the general principles of sampling, and especially of machine sampling, and advocates the use of his own continuous sampler.* This consists of two parts: a conical hopper ending in a cylinder and rotating on a horizontal ring supported by three posts and a stationary funnel-shaped receiver, in the center of which is a solid cone. The crushed ore passes through the rotating hopper, strikes the apex of the cone, and while spreading over its sides is divided by two segmentally shaped spouts into four parts—the original and duplicate samples and the two divisions of rejected ore. The separated samples pass through the spouts into boxes, and the rejected ore striking the converging sides of the funnel, glides downward toward the center, and is thence discharged into a bin or other suitable receiver.

A few examples of European practice in ore-sampling are given in *B. & H. Ztg.*, 1894, p. 45. At Antwerp, according to Landin, shipments of ore weighing as much as 300 tons are sampled all together, and only 2% taken as the first sample. After crushing this to the size of a hazelnut and carefully mixing it, it is spread out evenly over the floor and 10 kilograms are taken from all over the surface to be crushed through a 5-mesh sieve, after which one kilogram is reserved for moisture sample, the other nine for assay sample. This is then finely pulverized and reduced in quantity down to four bottle-samples. At Fahlun, according to Akerblom, the sample (500 lbs. from lots of from 50 to 100 tons) is crushed through a 20-mesh sieve and then quartered down in the usual way. Of the mechanical samplers, those of Bridgman † and Clarkson are described and illustrated.

Two mechanical samplers have still to be mentioned: that of Hooper,‡ consisting of a suspended spout with crank and a revolving wheel with cam which engages with the end of the crank, causing the spout to swing to and fro and discharge the ore it receives from a hopper to one or the other side of a vertical partition, thus dividing it into sample and rejected ore; and that of Potter,§ a complicated series of apparatus consisting of a screw conveyor which brings the ore from the car over a swinging chute into an inclined elevator with a double line of buckets of two capacities. These deliver the ore into a sample hopper, where that which comes from the smaller buckets forming the sample is kept separate from the other—the rejected ore. The latter goes directly to the conveyor, which returns it to the shipping car, while the sample is submitted to a second division similar to the first, the rejected ore being added to that from the first.

Shimer and Reifsnyder‖ have carried on systematic experiments to determine the accuracy of the ordinary method of reducing samples in the laboratory by quartering. They obtain their best results by first mixing the pulp dry, then moistening and again mixing before quartering, and flattening out the cone instead of spreading with the spatula.

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* See *E. & M. J.*, June 2, 1894, and also *B. & H. Ztg.*, 1894, p. 45.

† See *Tr. A. I. M. E.*, XX., p. 416.

‡ Patent No. 523,664, July 31, 1894.

§ Patent No. 523,731, July 31, 1894.

‖ *J. Am. Chem. S'y*, 1893, XV., p. 260.

Assaying.—H. van F. Furman has brought out *A Manual of Practical Assaying,* New York, 1893: pp. 390; few illustrations. The assayer will find in this book a helpful practical guide for the current methods of assaying used in the laboratories of silver-lead smelting works. The author, having been for years connected with this kind of work in Colorado, is well versed in his subject.

A new edition of Prof. B. Kerl's *Probirbuch,* Leipsic: pp. 185, figs. 84, has appeared, in which the assaying of ores, with the exception of iron, and fuels is treated in the concise, exhaustive manner characteristic of Prof. Kerl. It is to be hoped that a new English edition may soon appear; a translation of the first edition, by Brannt, Wahl and Garrison, was published in 1883 by H. C. Baird, Philadelphia.

Two illustrations of muffle furnaces have appeared : one of the well-known Brown muffle assay furnace for a J. muffle, 12 in. long by 6 in. wide and 4 in. high;* the other, a muffle furnace for wood instead of the customary fuels.† It is described by Black. The furnace is one in use at a mining camp in Colorado where it is not easy to get any other fuel than wood; the muffle is 9 in. by 15 in.

Iles‡ calls attention to the unsatisfactory results obtained by the fire assay for lead. In one instance the dry assay of a galena concentrate representing forty umpire assays, gave 50.797% lead against 52.67% by the wet assay, Alexander's volumetric molybdate method being used, a difference of 1.873%; in another instance 50.69% was found against 52.58%, a difference of 1.91%; averaging the differences gives 1.891%, which is pretty close to 2%. While more lead is lost by the dry assay than is shown by this difference (an average sample of 700 lead buttons giving only 96.25% lead), it is made up by other substances entering the button.

The Denver Fire-Clay Company, of Denver, Colo., has for sale two fluxes (Nos. I. and II.). Flux No. III. of the table is the one recommended by

No.	Potassium Carbonate.	Sodium Bicarbonate.	Flour.	Glass Borax.	Powdered Borax.
I.	5	6½	2½	2½	.....
II.	2	2	1	.....	1
III.	16	16	8	4	.....

Furman in his *Manual of Assaying,* p. 68. Iles uses flux No. I. at his works in preference to No. II. His manner of carrying out the assay is as follows: Empty the sample crushed through a 100-mesh sieve upon a rubber cloth, mix it with the spatula and by rolling and spread to a layer $\frac{5}{8}$ in. thick; weigh 5 grams into a 5-gram crucible ($2\frac{5}{8}$ in. high, $2\frac{1}{4}$ in. wide at top, $1\frac{1}{4}$ in. at bottom, holding 65 c.c. of water), add a spoonful of No. I. flux (15 grams), mix with spatula (4 in. long, $\frac{5}{8}$ in. greatest width), tap, add 15 more grams, then from one to four one-penny nails (for slags or basic ores give an additional cover of 3 grams borax glass); place in muffle (12 in. wide, 19 in. long), heat for from fifteen to thirty minutes unto quiet fusion, remove crucible from muffle, nails from crucible, tap crucible three or four times, empty on to iron plate, stringing

* *E. & M. J.*, Sept. 15, 1894. † *S. M. Q.*, XV., p. 50. ‡ *Ibid.*, XV., p. 336.

out the slag to a thin point, when even the smallest lead button will be found. The slag has the form of a flattened-out "Prince Rupert's drop." In this assay the salt cover (unnecessary for fluxing and harmful as regards volatilization) is not used, and the cover (which prevents partial oxidation, *e. g.*, of antimony) is omitted.

Iles hopes that a general conference may be called to settle upon a standard method for lead assay, as was done for iron and steel at the suggestion of Langley.* A similar conference was proposed for the assaying of silver and gold in copper by Ledoux,† and the present writer‡ has advocated the advisability of having the comparative merits of scorification and crucible assays for silver in ores thoroughly tested and the results made public, with the view of arriving at a preferable standard method.

Iles, at the end of his paper, refers to the nineteen charges for lead assays given in the writer's *Metallurgy of Lead*, p. 70. He omits, however, to state that they are classified to give the reader the choice of four mixtures for ore or slag, one for slag alone and one for carbonate ore, and thirteen separate charges in detail for different classes of ores which are to be weighed out in case the ready-made mixtures should not prove satisfactory.

Low§ describes his permanganate and ferrocyanide methods for the determination of lead.

The Permanganate Method.—Dissolve 1 gram of ore in a 250-c.c. flask in 10 c.c. nitro-hydrochloric acid; boil, add 10 c.c. strong sulphuric acid, heat over naked lamp until white fumes come off; cool, add 50 c.c. water, heat to boiling, filter and wash with dilute (1:10) sulphuric acid. Spread filter on watch glass, rinse contents with 50 c.c. boiling ammonium chloride (cold saturated solution, one-half diluted) into small beaker; stir, decant into original 250-c.c. flask, add to residue (which may contain lead) a few c.c. strong caustic soda; boil, precipitate with sulphuric acid, avoiding excess, and rinse into beaker containing ammonium chloride solution with ammonium chloride. Precipitate lead with three pieces of sheet aluminum ($\frac{1}{16}$ in. thick, $\frac{5}{8}$ in. wide, $1\frac{3}{4}$ in. long); heat, boil for five minutes, fill flask with cold water, allow lead to settle and decant into dish; repeat this five times. Now add 5 c.c. dilute (1:2) nitric acid, warm, pour solution and aluminum foil into small beaker, return solution alone into flask, add one or two drops phenolphthalin, then a slight excess of strong caustic soda, lastly 10 c.c. cold saturated solution of oxalic acid; cool, filter, and wash with cold water. Place in flask 75 c.c. distilled water, add a few drops concentrated sulphuric acid; heat, drop filter and contents into solution and titrate at once with potassium permanganate, using a one-tenth normal solution. The factor for Fe $\times$ 1.888 gives the factor for lead. The results are accurate within 0.1% or 0.2%; none of the ordinary constituents interfere with the method.

The Ferrocyanide Method.—Proceed as before until lead sulphate and insoluble residue are collected on the filter, and wash with cold water. Place funnel in original flask, rinse, filter contents into it with about 50 c.c. cold water, add

* *Tr. A. I. M. E.*, XIX., p. 614; XX., p. 242. † *Ibid.*, Vol. XXIV. ‡ *Ibid.*, Vol. XXIV.
§ *J. Am. Chem. S'y*, XV., p. 548.

10 c.c. cold saturated solution of ammonium carbonate, heat to boiling (to convert calcium sulphate into carbonate); cool and filter through original filter, using cold wash-water. Place in flask 30 c.c. dilute acetic acid (1 part glacial acid to 5 of water) and heat; then put filter and contents in a large beaker and add the boiling dilute acetic acid; stir, and heat if necessary; dilute to 100 c.c. and titrate with potassium ferrocyanide (10 grams to the liter), using a saturated neutral solution of uranium acetate as indicator. With one gram ore 1 c.c. equals 1% lead. The time required for the assay is thirty minutes. In the presence of bismuth and antimony, add to the sulphuric acid evaporation 10 c.c. dilute (1:10) sulphuric acid and 2 grams Rochelle salts. When dissolved, add 40 c.c. water, heat to boiling and proceed as usual. As much as 38% of lime does not interfere with the result.

Beebe,* chemist of the Chicago and Aurora Smelting and Refining Company, determines the lead of ores and furnace products by converting it, through the stages of sulphate and carbonate, into acetate free from alkali, and then titrating with potassium ferrocyanide (11 grams to 1 liter), using a slightly acidified concentrated solution of uranium acetate as an indicator.

Canby,† praising highly Alexander's molybdate method for determining lead volumetrically, states that he prefers to dissolve the lead sulphate in ammonium chloride, as is done in Low's method above, and to add two or three grams of sodium acetate before titrating, instead of using ammonium acetate alone.

Low‡ calls attention to the fact that lime interferes with Alexander's molybdate method.

Stetefeldt§ discusses the inaccuracy of the commercial assay of silver ores, *i.e.*, the direct results obtained either by the scorification or the crucible method, in comparison with the corrected assay, the correction including the silver which remains in the slag and the cupel, while the loss by volatilization, which cannot be well ascertained, is left out of account. He also compares the crucible and scorification assays for silver ores, giving data in favor of the former. These will not be fully accepted by lead smelters without further evidence of a more detailed character. Similar work has been done by Dewey.‖

Oehmichen¶ has made some investigations about the loss of silver in cupelling, using fusible-alloy pyrometers with melting points varying from 600° C. to 900° C. to regulate the temperature of the muffle. Six cupels were placed two and two in the muffle, with a pyrometer between them, but as all these pyrometers fused it was impossible to tell the temperatures of the cupellations with any exactness. Nevertheless the results are of interest.

In Muffle at	Ounces per Ton.				
	Ag	Au	Ag	Au	Ag
Back	92.25	20.12	117.25	23.92	34.68
Middle	100.03	20.77	125.24	25.55	34.97
Front	105.29	20.99	130.08	26.55	35.44

The results would have been of more value if instead of assaying ore, in 25-

* *E. & M. J.*, July 17, 1894.
† *Ibid.*, Sept. 1, 1894.
‡ *J. Am. Chem. S'y*, XV., p. 548.
§ *Tr. A. I. M. E.*, XXIV.
‖ *J. Am. Chem. S'y*, 1894, XVI., p. 505.
¶ *Z. Angew. Ch.*, 1893, p. 723.

gram charges, in the crucible and cupelling the resulting lead buttons, weighing from 27 to 28 grams, the start had been made with base bullion. The figures for the amount of precious metal absorbed by the cupel are as follows: With 125 oz. base bullion they vary from 2.36% of the silver and 5.26% of the gold to 5% of the silver and 10.26% of the gold, the higher figures referring to the assays made at the back of the muffle.

Mason and Bowman* determined by synthetical experiments the loss of silver and gold in scorification and cupellation; they found that by scorification to be 0.55% of the silver and 0.574% of the gold; that by cupellation, 1.99% and 0.296%, respectively.

Smith† made some experiments on the losses in cupelling bismuth-silver alloys and found that they were much greater than those in the corresponding lead-silver alloys.

Furman‡ discusses the losses of gold and silver occurring in the fire assay. He calls attention to the importance of having a uniform sample of the ore, which can often only be had, especially with gold, after grinding through a 100-mesh sieve. He recommends that the weight of the lead button from either scorification or crucible assay shall not exceed 7 grams, even with assays running as high as 10 ozs. gold and 300 ozs. silver per ton, and that in assaying ores containing zinc, arsenic, and antimony in the crucible, it shall be run without a cover (see Iles, *ante*), to assist the volatilization and slagging of these metals. He gives in two tables data regarding the losses of silver in cupelling, varying the temperatures and the proportions of lead and base metals, such as copper, zinc, antimony, etc. He finds that ordinary base bullion, excepting that which is rich in zinc, need not be scorified before cupelling, and states that all cupels should be run so as to show feather-litharge, and be brightened at a higher temperature to eliminate the last traces of base metal. In a third table the loss of silver and gold in the crucible assay is discussed, the gangue of the ore being made up of mixtures of silica, zinc oxide, barium sulphate, iron sulphide, copper, lime, etc., to represent all ordinary conditions. The loss in silver is found to average 2.58%, that of the gold being nominal. The author finally lays stress on parting silver-gold buttons, which should contain at least 5 parts Ag to 1 part Au, with two acids, the dilute acid of sp. gr. 1.15 being followed by one of 1.27 sp. gr.

Torrey§ states that in his laboratory all cupellations are carried on at an uniform temperature, maintained by the use of a platinum pyrometer‖ which automatically regulates the gas supply heating the muffle.

Rosenlecher¶ discusses in an illustrated article the distribution of silver in base bullion, and after reviewing the customary methods of sampling, recommends a new one that gave most satisfactory results. In order to determine the distribution of silver, he sawed through lengthwise and crosswise three cakes of Mexican base bullion—each weighing about 80 lbs. and being 16 by 6 in. at the top, $15\frac{3}{8}$ by $5\frac{1}{8}$ in. at the bottom and 2 in. thick—then took chip samples and assayed them.

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* *J. Am. Chem. S'y*, 1894, p. 313; *E. & M. J.*, June 9, 1894; *B. & H. Ztg.*, 1894, p. 257.
† *J. Chem. S'y*, 1894, p. 863; *B. & H. Ztg.*, 1894, p. 257.
‡ *Trans. A. I. M. E.*, XXIV.; *E. & M. J.*, Nov. 3, 1894.
§ *Tr. A. I. M. E.*, XXIV.
‖ Invented by Taylor, and described in *E. & M. J.*, Aug. 28, 1886.
¶ *B. & H. Ztg.*, 1894, pp. 333, 341.

The results showed the top of the bar to be richer than the bottom, the sides to have a medium tenor in silver, the center to give the lowest assays, and the part below the depression on the surface (the last to solidify) the highest results. From the richest part outward there was a gradual decrease in value. He recommends as a new method of sampling to make with a saw (avoiding all lubricants) a horizontal cut into each bar, to be begun at the end nearest the depression on the surface and extended to beyond the middle, the sawings to be collected, mixed, reduced in bulk by quartering, and assayed. The peculiar distribution of silver in the Mexican cake must be owing to its form, as with ordinary American bars—say 30 in. long, 3 in. wide at the top, 2 in. at the bottom, 3 in. thick, weighing from 80 to 100 lbs.—the bottom is richer than the top or the middle. Sawing of bars in two as a means of sampling was suggested by Pattinson.* Sampling by sawing is giving very satisfactory results at one of our large smelting and refining works. The bullion is unloaded from the car into an inclined iron trough having rollers at the bottom over which it glides on to a table, where the sampler presses it against a vertical circular saw to make an incision extending halfway through the bar. The incisions are made successively in the first bar near one end, in the second near the middle, in the third near the other end, and so on. The results obtained agree very well with the usual punch samples taken diagonally across the bars, and also with the output of the refinery.

Williams† describes a method for determining arsenic, antimony, copper, bismuth, iron, zinc, and sulphur in base bullion, and Eastwick‡ one for arsenic alone.

The remarks of Peters in THE MINERAL INDUSTRY, Vol. II., p. 264, on the inaccuracy of the cyanide assay for copper, supplemented by notes in the *Engineering and Mining Journal* of Aug. 25 and Sept. 29, 1894, in which he states that his restrictions referred only to the direct process without previous isolation of the copper, have called forth remonstrances in the *Engineering and Mining Journal* of 1894, by Furman (Aug. 11), Smith (Sept. 1), Lungwitz (Sept. 15), and Low (Sept. 29).

The question of a uniform method for assaying copper-bearing ores and products for silver and gold was brought by Ledoux before the October (1894) meeting of the American Institute of Mining Engineers.§ He shows that the common scorification assay gives higher results in gold than the usual combined dry and wet assay, which he describes in outline, and suggests that a standard method should be arrived at by the combined efforts of assayers accustomed to this kind of work.

Heintorf‖ describes the assay methods for bismuth in use at the silver-lead smelting works of St. Andreasberg, Hartz Mountains. They are as follows: For litharge with about 0.02% bismuth, weigh out from twenty to forty samples of 12.5 grams each, mix with 25 grams flux (3 parts K_2CO_3, 2 parts Na_2CO_3, 1 part flour), charge into a small clay crucible, give salt cover ($\frac{3}{8}$ in.) and piece of charcoal and fuse in muffle. Scorify the lead buttons until one button weighing from 40 to 50

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* THE MINERAL INDUSTRY, Vol. II., p. 438. † *Proc. Eng. S'y West Penn.*, 1894, X., p. 28. ‡ *Op. cit.*, p. 32.
§ See *Tr. A. I. M. E.*, XXIV. ‖ *B. & H. Ztg.*, 1894, p. 351.

grams results; hammer and roll this out and cut into small pieces. Dissolve in dilute nitric acid, precipitate lead with sulphuric acid, silver with a few crystals of salt, filter and wash ten or more times with water acidulated with sulphuric acid; reduce volume of filtrate on sand-bath, precipitate bismuth with ammonia and ammonium carbonate, filter and wash with hot water; dissolve bismuth carbonate from filter with dilute hydrochloric acid, washing with the acid until the filtrate does not tarnish a bright iron wire, then with water; precipitate bismuth with iron wire, and when completed—testing again with bright iron wire—pour off supernatant liquor, wash with hot water by decanting, transfer bismuth and remaining iron wire into porcelain dish, brush adhering bismuth from wire with fingers, remove the wire, wash bismuth several times with hot water by decanting, dry on sand-bath and weigh. If necessary, on account of floating bismuth, pour wash-water and bismuth on a weighed filter, then dry and weigh. For cupel-bottom with from 0.2% to 5% bismuth, mix 5 grams cupel-bottom with 15 grams of same flux as above, adding some glass borax and glass, give salt cover and piece of charcoal, reduce in muffle, etc., and treat lead button as before. For crude silver, dissolve 5 grams in nitric acid, precipitate silver with salt, lead with a few drops of sulphuric acid, bismuth with ammonia and ammonium carbonate, and proceed as already shown. In order to test the accuracy of the method, the bismuth from fourteen samples of refined lead was determined by the assay method just described (500 grams of each sample being scorified down to 40 or 50 grams) and by the regular chemical analysis. The subjoined table shows the accuracy of the method:

PERCENTAGE OF BISMUTH.

Assay	0.0190	0.0450	0.0130	0.0170	0.0170	0.0250	0.0350
Analysis	0.01889	0.04590	0.01223	0.01679	0.01750	0.02577	0.03299
Assay	0.0120	0.0120	0.0160	0.0180	0.0165	0.0150	0.0225
Analysis	0.01231	0.01255	0.01605	0.01878	0.01658	0.01558	0.02331

Purchasing of Lead-Silver Ores.—Furman* discusses in a most interesting manner the purchasing of silver, gold, and lead ores in Colorado. He considers separately the assay value (silver, gold, lead, and copper), composition, character (coarse or fine), and scarcity of the ore at the time of purchase; he then takes up the cost of roasting and smelting, including the losses in each operation and the market value of the base bullion, and finally illustrates the method for calculating the cost of treatment and the resulting net value of the ore by three examples. In calculating the cost he starts, as is customary, with the so-called neutral ore, and gives the composition as: SiO_2 30%, Fe 30%, Pb 13%, Zn 8%, S 5%, and the cost of treatment, in Denver or Pueblo, for a 400-ton plant, as $4.50 per ton. He debits the ore with $0.15 for each unit of SiO_2 in excess of the Fe, and credits it with the same amount for each unit of Fe in excess of SiO_2, while the unit of CaO is credited with only $0.06. MgO and BaO being figured at the same rate, if their sum does not exceed 4% or 5% in the resulting slag. A deduction of $0.50 is finally made for every unit of zinc above 8%. The roasting in Pearce's furnace is estimated at $1 per ton, in the hand-reverberatory furnace without fusion at $2.25, and with fusion at $2.50 and $2.75 per ton. In this connection attention

* *S. M. Q.*, XV., p. 1.

may be again called to the valuable detailed estimates of cost of roasting published in the *Engineering and Mining Journal*, Dec. 30, 1893.

Collins, in his paper, referred to later, also treats of the purchasing of ores.

SMELTING OF LEAD ORES.

New Publications.—A Spanish metallurgy of lead, *Metalurgia del Plombo*, by D. Manuel Sanchez y Massia, was published in Madrid in 1893. It deals only with smelting, and contains many details of the Spanish practice not found in English, French, and German books.

C. Schnabel's *Metallurgy of Non-Ferrous Metals*, Berlin, 1894: Springer, pp. 914, figs. 571, Vol. I.: treating of copper (pp. 1–276), lead (pp. 276–462), silver (pp. 462–777), and gold (pp. 777–901), is a valuable contribution to metallurgical literature. In form and arrangement it resembles the usual German text book, but the author has omitted almost everything that is antiquated and useless to the modern metallurgist. He is very impartial, and American methods receive their just share of recognition.

Freiberg's *Berg- und Hüttenwesen*, Freiberg, 1893, describing the mines, ore dressing and smelting works of Freiberg, Saxony, has appeared in a new and enlarged edition; the first edition was published in 1883. The metallurgical part is of interest to the American lead smelter as showing how in a large conservative European plant by-products, which it is not considered profitable to treat here, are worked up.

In General.—Hannay,* in a paper read before the Royal Society of London on the metallurgy of lead, makes a number of startling statements. He asserts that lead sulphide forms with carbon dioxide, water, sulphur dioxide, and carbon monoxide volatile compounds which are stable at a red heat, but dissociate on cooling; also that the accepted

$$PbS + PbSO_4 = Pb_2 + 2SO_2$$

of the roasting and reaction process is incorrect, and should be

$$24PbS + 22O_2 = 17Pb + 2(\underbrace{PbS.\ PbO + PbSO_4}_{\text{Gray Slag.}}) + \underbrace{PbS_2O_2}_{\text{Smoke.}} + 17SO_2$$

PbS_2O_2 being a volatile compound. He suggests that galena should be bessemerized in a converter when not

$$2PbS + O_2 = Pb + PbS_2O_2,$$
$$\text{but } 2PbS + O_6 = Pb + PbSO_4 + SO_2$$

would be formed. The silver of the ore would be concentrated in the lead and the lead sulphate collected in dust chambers. Few metallurgists will care to try a method so opposed to tradition and experience.

Roesing and Foerster† propose to pour fused lead sulphide into highly heated lead oxide, in weighed quantities. By the interaction of the two, lead and concentrated sulphur dioxide will be set free, the latter to be utilized in making sulphuric acid. Sufficient heat will be generated by the reaction to make any further external heating unnecessary. An illustration of the apparatus accompanies the article in the *Chemiker Zeitung*.

Chem. News, Vol. LXVII., p. 291, and Vol. LXIX, p. 195; *J. Chem. S'y*, abstracts, 1893, II., p. 464; *Ch. C.*, 1893, II., p. 302, and 1894, I., p. 1127; *B. & H. Ztg.*, 1894, p. 328.

† *J. S'y Chem. I.*, 1893, p. 12; *Ch. Ztg.*, 1893, p. 4.

In the Reverberatory Furnace.—Nicke* applies his method of graphometric calculation to the reactions that occur in the treatment of lead ores in the reverberatory furnace and the ore hearth.

The drawing of the gray slag from the reverberatory furnace is always a hard operation for the workmen on account of the great heat and the unhealthy fumes. If the slag is discharged into a water-box, the amount of fume is diminished, but the danger is increased by the explosions which are liable to occur, especially if the slag is rich in lead. The whole difficulty has been overcome at Tarnowitz, Prussia, by a very simple device.† A niche, *a*, 30 in. wide, 26¼ in. deep, and 26¼ in. high (see Fig. 1); is left open beneath the drawing door, *b*, to

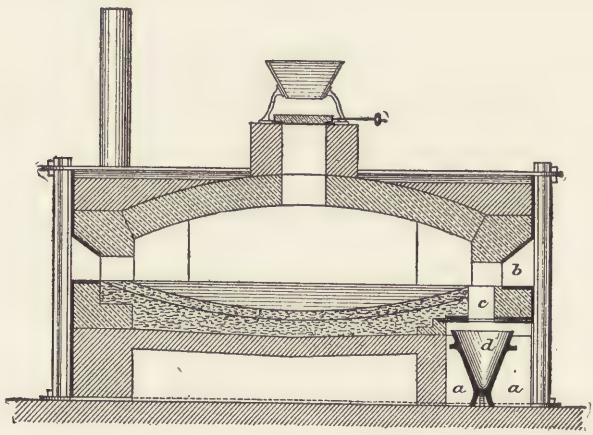

FIG. 1.—VERTICAL CROSS-SECTION.

receive a slag-pot, *d*, which is brought on a separable car. The back and sides of the niche are enclosed by brick work. The roof is formed by a heavy cast-iron plate to support the brick work and the hearth. The plate has an opening, *c*, 7½ in. square (beginning 15 in. from the outside wall) through which the gray slag is raked into the pot. It is closed with an iron plate when not in use. When the slag is being drawn, the front of the niche is closed by a movable sheet-iron door having a peep-hole; all the fumes from the slag pass through the drawing opening back into the furnace. When it has cooled sufficiently the slag-pot is covered with a piece of sheet iron and drawn out on the car. Another source of lead poisoning is the fumes issuing from the lead basin near the flue of the furnace after the lead has been tapped. This also is now drawn back into the furnace. The beneficial effect of these improvements is shown by the fact that while in the year 1887–88, 28.5% of the men became leaded, in 1891–92 only 0.8% were thus affected.

In the Ore Hearth.—Petraeus‡ makes the claim that the white paint made by the Pitcher Lead Company has a superior covering capacity and is altogether preferable to white lead made by the Dutch process. It is a mixture of lead sulphate and lead oxide produced by smelting blue powder from the ore hearth with gray slag in the Moffat slag-eye furnace and collecting the fumes.

* *Z. Phys. Ch.*, XI., p. 598. † *Pr. Z.*, XLI., p. 271; *B. & H. Ztg.*, 1894, p. 299. ‡ *E. & M. J.*, Oct. 13, 1894.

The concluding paper on the zinc and lead-mining industry of southwestern Missouri and southeastern Kansas by Hollibaugh* gives the history of the Pitcher Lead Company, of Joplin, Mo., and describes the present manner of treating the ore. The changes to be noted in the apparatus and method of working† are that the hot gases and fumes pass through a water-jacketed flue before reaching the brick flue, that some crude galena is added with satisfactory results to the ordinary charge of the slag-eye furnace, and that lastly the percentage of lead in the refuse slag has been reduced from 25% to below 10% by adding fluxes to the charge. Since the slag-eye furnace has been wholly water-jacketed it can stand a more fluid slag than before. The works treat daily 168,000 lbs. of galena and 1600 lbs. carbonate ore, and their white pigment is used for paint, in the manufacture of oil cloth, stained paper and rubber goods.

E. O. Bartlett has patented‡ improvements on his method of producing and collecting white lead pigments from galena ores. They consist mainly in changing the form of the ore furnace from an ore hearth to a low cupola furnace entirely surrounded by water jackets, preventing the furnace fumes from igniting while passing through the dust chambers and filtering apparatus, changing the form of the pigment furnace and the manner in which it is connected with the dust chamber and the cooling and filtering apparatus, and feeding the collected ore fumes with the blast through an upper row of tuyères into the glowing coke of the pigment furnace, which is kept at the desired temperature by a lower row of tuyères. C. V. Petraeus and E. O. Bartlett§ combine the operations of the ore and pigment furnaces by charging a low cupola with slag-forming material and coke, and injecting with an air blast finely pulverized galena into the upper hot parts, where it is volatilized and oxidized. The resulting coarse flue dust and fine white fumes are then collected by dust chambers and filter bags.

In the Blast Furnace.—Lunge‖ gives a short outline of the smelting and refining operations carried on by the Globe Smelting and Refining Company, at Denver, Colo., and the Chicago and Aurora Smelting and Refining Company, at Aurora, Ill.

Collins¶ describes with drawings the smelting processes in use in this country for the extraction of silver and gold from their ores under the two heads: "Lead Smelting" and "Extraction by Means of Metallic Copper." Under "Lead Smelting" the general features of the American practice are discussed, including the purchasing of ores and the calculation of charges. The works at El Paso, Texas, are described, a plan being given which shows the general arrangement in a very satisfactory way. Reference is also made to the works at Las Trojes, Michacoan, Mexico. The same works are described in detail by Malcolmson** in a well illustrated paper. He gives a plan showing the general arrangement of the plant, plan and sections of the smelter building and two detail drawings of the blast fur-

* *E. & M. J.*, Oct. 27, Nov. 3, 10, 17, 24, Dec. 1, 8, 1894.
† See Hofman, "Lead," p. 113, *et seq.*
‡ Patents Nos. 515,038 to 515,042, Feb. 20, 1894.
§ Patent No. 515,459, Feb. 27, 1894.
‖ *St. & E.*, 1894, p. 212; *B. & H. Ztg.*, 1894, p. 309.
¶ *Proc. Inst. Civ. Eng.*, 1893, Vol. CXII., p. 112; *J. S'y Chem. I.*, 1893, p. 767.
** *Proc. Inst. Civ. Eng.*, 1893, Vol. CXII., p. 164; *J. S'y Chem. I.*, 1893, p. 766.

nace. There are two American water-jacket blast furnaces, 36 by 84 in. at the tuyères, and 12 ft. 6 in. high from tuyères to throat; the tuyères are of the Devereux pattern. The down-take of the furnace is a 3-ft. wrought-iron pipe; the dust chamber (6 by 8 ft.) is carried up a hill to a height of 350 ft. Three No. 5½ Baker blowers deliver the air into one 3-ft. wrought-iron main. They are driven by a 6-ft. Pelton wheel. Three hundred and fifty cubic feet of water per minute under a 487-ft. head pass through a 12-in. feed pipe and 2½-in. nozzle which would correspond to 253 horse-power. The ore is a mixture of iron and zinc sulphides, carrying from 15% to 30% silica and silver in the form of sulphide and arsenide. It is heap-roasted, whereby the sulphur is driven off to from 5% to 8%, and then smelted with litharge in the blast furnace, the fuel used being a mixture of coke and charcoal (1:2¼). The resulting base bullion assays 130 oz. silver per ton, the iron matte 20 oz., the slag from 1 to 1½ oz.

Bräuning* and Fuhrmann† give a review of the occurrence, methods of mining and treatment of copper, zinc, lead, silver, and gold ores in the United States. The papers do not go much into detail and offer little about the metallurgy of argentiferous lead that has not already appeared in print.

Jamieson and Buchanan‡ describe the mining and ore treatment at Broken Hill, New South Wales. The processes in present use for extracting the silver from the ores are four: Smelting for carbonate lead ores and sulphide and carbonate concentrates, the base bullion produced being desilverized by the Parkes process; concentrating for sulphide and oxide ores; leaching for tailings from the concentrating works, and amalgamating for dry silver ores. A satisfactory method for treating low-grade sulphide ores occurring below water level has still to be introduced.§

Lead Slags.—There has never been until recently any attempt to bring the typical slags used by lead smelters into a related order. They have been taken simply as required in an isolated way. L. S. Austin‖ has tried to systematize their connection by plotting them. His diagram is here reproduced (Fig. 2). The straight line *ss'* represents the amounts of SiO_2, running from 25% to 40%, the upper curved line *ll'* the percentages of CaO and FeO in the main typical slags, and the lower one *ii'* the same in a series running especially high in iron; *tt'* is a tangent parallel to line *ss'*. The capital letters give the slags from the table of the writer's *Metallurgy of Lead*, p. 135; those with the (') have been multiplied with the proper coefficient to make their sums add up to 90%, so as to permit their being plotted with the rest. The composition of slag C, *e.g.*, is read in the diagram as follows: Taking the ordinate running through the point C, the distance from the bottom to the intersection of line *ss'* represents the amount of SiO_2—28%—the distance from this to the point C the amount of CaO—12%—and the distance from C to the top the amount of FeO—50%. With the exception of slags A, B, and D, which have fallen into disuse, and type I, which appears to belong to a separate class, all slags fit into two groups. Both curves show that with an increase of SiO_2 there is an increase of CaO and that if from the point where CaO= FeO, *i.e.*, at SiO_2=37%, a parallel *tt'* is drawn to the silica-line *ss'*, the

* *Pr. Z.*, 1894, XLII., p. 243.
† *Ibid.*, p. 286.
‡ *Proc. Inst. Civ. Eng.*, 1892-3, Vol. CXIV., p. 116.
§ See THE MINERAL INDUSTRY, Vol. II., p. 431.
‖ *E. & M. J.*, Jan. 27, 1894; *B. & H. Ztg.*, 1894, p. 103.

permissible variations in the relative proportions of FeO and CaO increase with the decrease of SiO_2, and lastly that with a high percentage of SiO_2 the totals are liable to add up to more than 90%, which means that highly siliceous slags are better suited for clean, easy ores than those having many bases other than FeO and CaO.

Analyses of some ores and slags of the ancient Greeks are given in a paper on the lead-silver mines of Laurium by Gobantz.*

Gümbel† gives the composition of a crystallized lead slag made at Freyhung, Bavaria: SiO_2, 33.04%; Al_2O_3, 1.10%; F_2O_3, 7.91%; FeO, 31.53%; MnO, 1.16%; CaO,

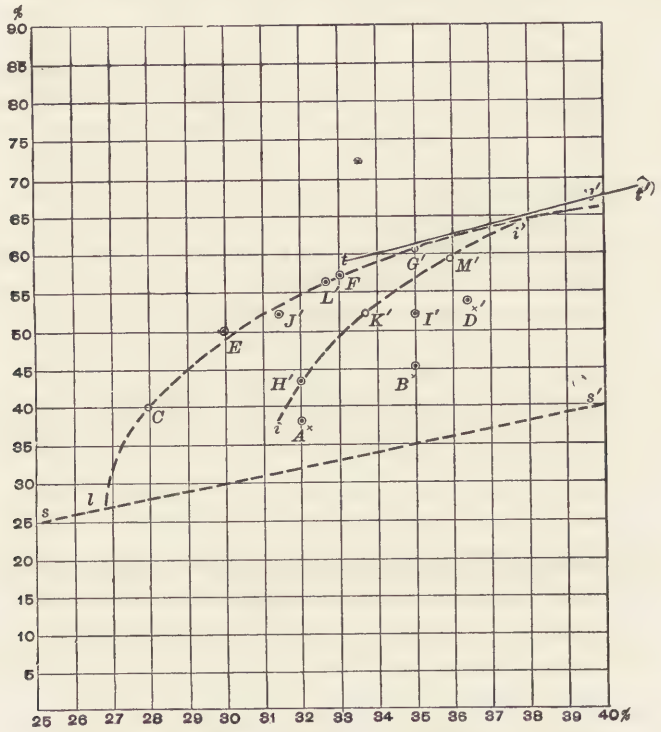

FIG. 2.—DIAGRAM SHOWING COMPOSITION OF SLAGS.

Line *ss'* represents percentage of silica; *ii'*, an irony series of slags; *ll'*, main typical series of slags; *tt'* is tangent parallel to *ss'*.

23.52%; MgO, 1.18%; K_2O, 0.58%; Na_2O, 0.24%; P_2O_5, 0.31%—total, 100.57%; and the specific gravity as 3.580. The small crystals were rhombic needles of the form of monticellite, the singulo-silicate of lime and magnesia: $(CaMg)_2\ SiO_4$.

Action of Fluxes.—Church‡ writes about manganese slags made at Tombstone, Ariz., giving full data of the work done from 1882 to 1887, when he was in charge. In a paper written some time ago§ he showed that slags rich in manganese do not necessarily run high in silver.

Influence of Foreign Matter.—Emmens proposes‖ to treat zinc-lead sulphide ores by roasting the pulverized ore, leaching out the zinc sulphate with water

* *O. Z.*, 1894, p. 123.
† *Ch. C.*, 1893, II., p. 1023.
‡ *Tr. A. I. M. E.*, Vol. XXIV.
§ *Ibid.*, Vol. XV., p. 612.
‖ Patent No. 513,490, Jan. 30, 1894.

containing ferrous sulphate, and then sulphatizing and removing the remaining zinc sulphide and oxide with a solution of ferric and ferrous sulphate. Lastly he washes with water containing ferrous sulphate. The iron contained in the zinc solutions is to be removed.

Ingalls and Wyatt have patented* a modification of the Parnell process of treating zinc ores. They propose to roast the ore, then leach with water and sulphuric acid, separate one-quarter of the filtrate and precipitate from it zinc sulphide with an alkaline sulphide, evaporate to dryness the rest of the solution, mix the zinc sulphate obtained with the precipitated zinc sulphide, and heat, when zinc oxide and sulphurous acid are formed. E. O. Bartlett† reverses the usual method of making zinc oxide directly from ore, in which the blast is introduced from beneath the grate, by admitting it from the roof on to the charge placed on glowing coal which rests on a suitable grate, drawing off all the fumes through the grate and ash pit into settling chambers and filtering apparatus. Klöz has patented‡ a process for removing zinc from sulphide ores. It consists in roasting the ore and extracting the zinc in the form of sulphite with a concentrated aqueous solution of sulphurous acid.

Hunicke§ gives the results of a set of experiments in treating roasted zinc ores in the blast-furnace, ore and coke being heated separately in kilns up to 1300° C., and then charged in alternate layers into the blast furnace,‖ whence the fumes produced by the almost instantaneous reduction were conducted through a chamber filled with hot coke into a receiver.

Fuels.—The example of Neill in using mixtures of coke and bituminous coal instead of coke, or coke and charcoal, has been followed by others, and proved successful.

Blast Furnace Fuel.	Cost Per Ton.	Character.	Per Cent. Ash.	Composition of Ash, Per Cent.				Calorific Power, Grams Lead Reduced by 1 Gram Fuel.	Coke: Coal.			Coke: Coal.			Coke: Charcoal: Coal.		
				SiO_2.	FeO.	CaO.	Cu.		Proportions in Mixture.	Cost Per Ton Charge.	Per Cent. of Mixture.	Proportions in Mixture.	Cost Per Ton Charge.	Per Cent. of Mixture.	Proportions in Mixture.	Cost Per Ton Charge.	Per Cent. of Mixture.
Coke from Castle Gate, Utah.....	$7.50	Friable ..	14.0	35.0	25.7	6.5	2.6	24.5	14:2	$1.33	16	12:4 9:9	$1.09 0.94	16 18	9:2:6	$1.07	17
Coke from Crested Butte, Colo.....	11.00	Fairly Hard	11.3	32.2	30.4	6.6	2.8	28.5	14:2	1.82	16	12:5 9:9	1.47 1.26	17 18	.....	.....	....
Nut Coal from Castle Gate, Utah...	3.00	Friable ..	8.4	42.0	20.8	10.0	....	24.0	....	.....	....	....	.....	....	.....	.....	...
Charcoal.....	14.00	.....	....	....	....	....	....	.....	....	.....	....	....	.....	....	.....	.....	....

L. S. Austin ¶ gives a summary of eighteen months' experience in the use of mixed fuels—coke, charcoal, and bituminous coal—in the blast furnace (having a 12-ft. working height) of the Germania Lead Works, Salt Lake City, Utah. The preceding table contains the important data.

The conclusions drawn by Austin are, that in replacing charcoal and some of the coke by bituminous coal, the amount of fuel required to the ton of charge has to be increased by 1% or 2%; that the effect is similar to that of charcoal in promoting the running of the furnace, but that an excess of bituminous coal is liable to

* Patent No. 516,016, March 6, 1894.
† Patent No. 515,043, Feb. 20, 1894.
‡ Patent No. 518,890, April 24, 1894.
§ *E. & M. J.*, Sept. 15, 1894.
‖ THE MINERAL INDUSTRY, Vol. II., p. 431.
¶ *E. & M. J.* Dec. 15, 1894.

choke up the charge and can be corrected by substituting charcoal; that bituminous coal appears to work unfavorably with coppery and arsenical ores, the crucible filling up slowly; that as regards manipulation, the feeding of bituminous coal must be stopped wherever yellow smoke issues from the surface of the charge; that over-fire is to be avoided, as it ignites the explosive gas-mixture on its passage into the down-comer, and that lastly the blast may never be taken off entirely (at least one blower must be kept going), as the same mixture coming in contact with air in the furnace will be ignited by the hot charge. The replacing of charcoal and coke by bituminous coal is recommended, if the latter is considerably cheaper, and if copper and arsenic are present in small enough quantities to permit its use.

Roasting of Ores.—Stickney patented* a roasting process and apparatus by means of which he expects to recover sulphur by making steam act on agitated red-hot ore and oxidizing only the hydrogen of the hydrogen sulphide set free. Stover patented† an ore-roasting and smelting furnace. The roaster, which suggests the old Whelply-Storer furnace, consists of a shaft furnace contracting toward the top, where are the fireplaces and feeding apparatus for finely pulverized ore. The ore is roasted while passing with the flame down the shaft, and is settled in a series of spray dust chambers; the fine dust particles are collected by a spray wheel, and the gases finally made to pass through a checker work in the bottom of the stack. If the roasted ore is to be smelted, the shaft is mounted on the hearth of a reverberatory furnace, with its usual fireplace, but having an arrangement for introducing finely divided fuel at the rear wall by means of a tuyère-pipe. Walker and Carter patented‡ an improved form of their retort furnace proposed many years ago§ for roasting silver ores. Butterfield patented‖ a cylindrical revolving roasting furnace similar to a White furnace. It has a stationary gas supply pipe in the center, from which a series of burners project radially downward that the flame may heat the ore as it passes from the receiving to the discharge end, and a small spray pipe that the roasted ore may be treated with water or other suitable solvents after it has been roasted to the desired degree.

The Brown horseshoe furnace,¶ described and illustrated in the *Engineering and Mining Journal*, May 12, 1894, is a mechanical reverberatory roasting furnace. It is ring-shaped and occupies four-fifths of the annular space, the other fifth being an open span. The furnace has on the outer side four external fireplaces, and on the inner side working doors of the usual form to admit air and to permit working on the hearth if necessary. The hearth is separated on either side from the furnace walls by a partition wall divided through the middle to accommodate the arms of the rake which connect with the moving mechanism between the furnace wall and the partition. Thus the mechanism is protected from the heat and the gases of the hearth. It consists of two pairs of small trucks attached to two cables running around horizontal sheaves. They carry along the stirrers which move the ore gradually over the hearth to the discharge, and are also the means by which it is automatically fed into the furnace. Air

* Patent No. 512,235, Jan. 2, 1894.
† Patents Nos. 516,662 to 516,664, March 20, 1894.
‡ Patents Nos. 516,781 to 516,784 and No. 516,854, March 20, 1894.
§ *E. & M. J.*, April 19, 1884; Dec. 31, 1887.
‖ Patent No. 518,662, April 24, 1894.
¶ Patent No. 519,317, May 8, 1894.

is admitted at the sheaves, which keeps these cool and furnishes part of the necessary oxygen. The two pairs of rakes are used alternately at intervals of two minutes, one pair being automatically released to cool in the open air while the other is taken on to replace it. A 55-ft. furnace roasts thirty tons "average" sulphide ore in twenty-four hours, and requires one cord of wood for six and a half tons of ore. If it is desired to use the furnace for ore that is to be agglomerated or fused, the red-hot roasted ore is discharged through a hopper into a receiver and thence transferred in cars to the melting furnace. Attention may be called to a somewhat similar horseshoe furnace by Keller.*

Prudhomme patented† a mechanical roasting furnace with stationary hearth, the ore being moved by plows resting on a truck drawn by an endless chain from the flue to the fire bridge of the furnace. Rudge patented‡ a mechanical semi-annular roasting furnace heated from an external fireplace in the usual way. The ore fed at the flue is moved toward the bridge by stirrers attached to horizontal arms inserted in a central driving shaft. The horizontal slit in the inner wall through which the stirring arms pass is lined with two water troughs; rollers supporting the arms travel in the lower trough and curtains attached to the arms and reaching into both troughs close the slit. Roger patented§ a set of radial rabble arms for an annular mechanical roasting furnace. Air passes through the stationary column and the revolving hub into the radiating arms.

The roasting furnace of Tarnowitz, Prussia, 33 ft. by 12½ ft. inside dimensions, in which mixed lead ores with 10% zinc are roasted and fused, has a niche on either discharging side, with a slag-pot similar to that of the reverberatory smelting furnace. The niche is 3½ in. square and 22 in. high, the roof is arched, and the drawing door in the hearth 7 in. square. In this connection attention may be called to a similar arrangement of the slag-roasting furnaces at Przibram, Bohemia.‖

The patents¶ for Blake's roasting furnace, referred to in THE MINERAL INDUSTRY, II., p. 432, were issued Jan. 30, 1894. Vattier patented** a furnace for roasting finely divided metallic copper and other ores. Davis†† has introduced vertical partitions in the combustion chamber of his well-known shaft roasting furnace.

Goodwin patented‡‡ a mechanical roaster consisting of a stationary long-hearth reverberatory furnace in which revolves an inclined cylinder attached to a hollow perforated shaft connected with a blower. The cylinder is externally heated from the fireplace of the reverberatory furnace. The ore traveling slowly through the cylinder receives the air necessary for oxidation through the hollow shaft and is discharged into an iron box forming the roof of the fireplace. Thence it is moved toward a receiver by a screw conveyor.

Pierce patented§§ the combination of a revolving externally heated roasting cylinder with a stationary retort into which the roasted ore is discharged. The flame, after playing around the retort passes off through a flue and then heats the roasting cylinder.

Iles‖‖ counteracts the strongly corrosive effect of sulphuric acid contained in

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* See THE MINERAL INDUSTRY, 1893, p. 432.
† Patent No. 522,853, July 10, 1894.
‡ Patent No. 523,487, July 24, 1887.
§ Patent No. 523,650, July 24, 1894.
‖ *O. J.*, 1890, p. 12.
¶ Patents Nos. 513,754 and 513,755.
** Patent No. 511,476, Dec. 26, 1893.
†† Patent No. 520,481, May 29, 1894.
‡‡ Patent No. 527,746, Oct. 16, 1894.
§§ Patent No. 530,125, Dec. 4, 1894.
‖‖ Patent No. 515,084, Feb. 20, 1894.

the gases of roasting furnaces by bringing them, while still hot, in contact with a smoky flame issuing from a separate fireplace; the finely divided carbon is to reduce the sulphuric acid to less harmful sulphurous acid when the solid particles contained in the fumes can be separated from the gases by filtering through bags, or other screening appliances. Butterfield patented* a wet filtering chamber to save fumes from roasting furnaces.

The Blast Furnace.—Peele† describes and illustrates by a photo-lithograph a primitive furnace used by the Indians in central Bolivia. C. M. Allen has patented‡ a mechanical feeding apparatus for an oblong blast furnace, based on the principle of the bell and hopper commonly used with the circular iron blast furnace, the usual bell being replaced by an A-shaped roof and the hopper by a V-shaped trough.

In order to prevent lead from leaking through the crucible wall at the front of the furnace and passing off over the slag spout, Iles§ embeds a perforated water pipe beneath the slag spout in the upper front wall, thus cooling it and preventing the lead from rising above the level of the pipe. Iles patented‖ a device for separating matte and slag. The crucible is partly internal and partly external. On the fore-hearth and attached to the front jackets is placed a U-shaped water-cooled casting having a matte-tap and a slag-overflow that can be raised and lowered to alter the level of the slag. He also proposes¶ to tap matte and slag from the closed breast of the blast furnace through a curved spout into an oblong movable fore-hearth placed with one side against the front of the furnace. The melted mixture from the blast furnace is delivered at one end of the fore-hearth, the clean slag runs off at the other into a double side dumping slag-pot, while the clean matte, when it has sufficiently accumulated, is tapped at intervals underneath the curved slag spout. The fore-hearth is an iron box on wheels, consists of separate bottom and side plates that can be clamped together, and is lined with firebrick and non-conducting material.

Mathewson has again improved** his furnace-tap. It now consists (Figs. 3 to 8) of a detachable cast-iron fore-hearth G, from which the clean slag overflows continuously, and a matte-tap E^1 placed at the usual level. A water-cooled tymp K closing the upper breast of the furnace is fastened by bolts to the front jackets B. The detachable fore-hearth G consists of two water-cooled cast-iron sides, joined at the lower ends by the water-cooled matte-tap E, and a front plate H, usually not water cooled. Sides and matte-tap are held in place at the bottom by the front wall of the crucible A, and at the top by two key-bolts; the front-plate is attached to the sides by lugs. The slag which separates from the matte in the furnace enters the fore-heath through the opening E^2 and overflows on the side through the opening G^2 into the slag-spout J, which can be raised and lowered, as desired, in the guides G^1. The matte is tapped at intervals in the usual way. This fore-hearth, weighing not over 300 lbs., has many advantages. It permits a continuous regular discharge of slag and a good separation of matte and slag in the hot furnace, both being obtained as clean products; a bar can be

* Patent No. 516,674, March 20, 1894.
† *S. M. Q.*, XV., p. 8.
‡ Patent No. 522,446, July 3, 1894.
§ Patent No. 515,085, Feb. 20, 1894.
‖ Patent No. 515,083, Feb. 20, 1894.
¶ Patent No. 522, 417, July 3, 1894.
** Patent No. 515,244, Feb. 20, 1894.

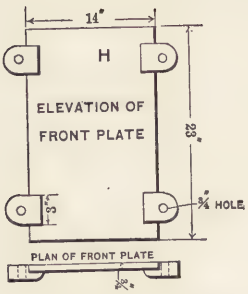

FIG. 3.

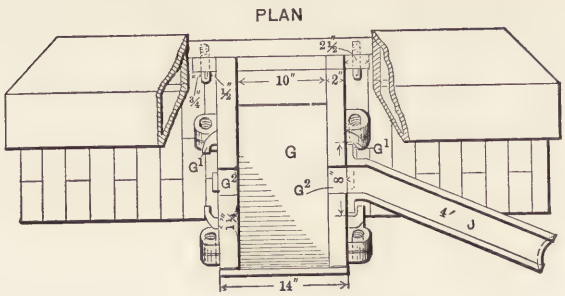

FIG. 4.

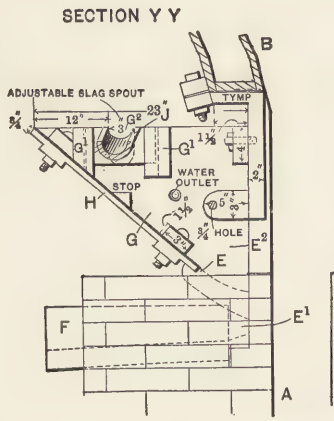

FIG. 5.

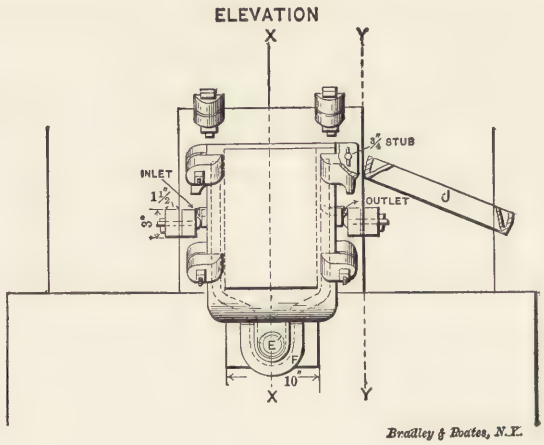

FIG. 6.

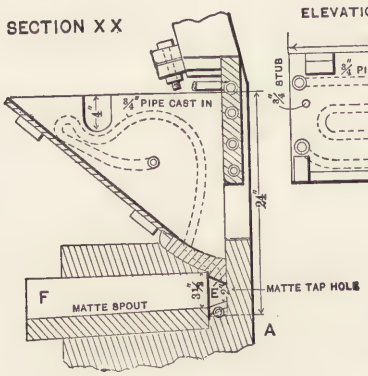

FIG. 7.

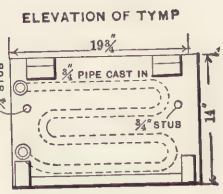

FIG. 8.

MATHEWSON'S IMPROVED FURNACE TAP.

introduced from the top of the fore-hearth through the matte or any crust that formed into the lead while the furnace is running, and in case of accident the fore-hearth and tymp can be removed, together or separately, in a few minutes, and the entire breast of the furnace laid open for work. In some cases it may be found convenient to tap slag and matte in the usual way through the matte-tap E. The fore-hearth finally can be readily attached to any existing furnace, the only change necessary being a new set of front jackets. The fore-hearth is doing satisfactory work at the furnaces of the Pueblo Smelting and Refining Company, Pueblo, Colo., and is adapted for any furnace smelting not less than 50 tons of charge in twenty-four hours.

Terhune* found in granulating his waste blast-furnace slag that the separation of matte and slag, when entirely effected in the ordinary catch-pot, with tapping hole for waste liquid slag, was imperfect. His attention was called to this by the small explosions which occur when even small particles of liquid matte come into contact with water.

Saeger† describes and illustrates an overflow pot used at Tarnowitz, Prussia, which is similar to the one first constructed by the Orford Copper Company, of Bergen Point, N. J.

General Smelting Operations.—Lang‡ gives a few points on blast-furnace practice, some new and some old. One of the latter is the withdrawing of a steel bar from the tap-hole by slipping over it a heavy steel ring and inserting behind this a wedge, which is then driven with a sledge. The best kind of ring for this purpose has a handle. Hutchings§ says that he has been using this method of getting out a bar that happens to stick fast in the tap-hole at his works in Wales for the last twelve years, and has employed for ten years the water-cooled slag-spout which has lately‖ come into use here. Lang also makes the opening of the matte-tap easy by inserting directly after stopping the tap-hole a ¾-in. iron bar through the soft clay plug, and keeping it there until the tap is to be opened again, when the bar is removed with the ring and wedge above mentioned. To prevent the breaking out of the matte-tap, he finds it helpful to force the clay plug well into the tap-hole by a few slight blows of the sledge, the usual light stopper-rod being replaced by a ½-in. pipe, from 6 to 7 ft. long. He mends a cracked slag-pot by drilling two ¾-in. holes on opposite sides of the crack, about 4 in. apart, and countersinking them on the inside. He then heats an iron rod, 7 in. long, with ends bent to go through the holes, and after adjusting it heads the ends on the inside. When fine ore appears at the tuyères he does one of several things: he lets down the charge somewhat, diminishes the blast, inserts a tube through the tuyère-pipe, thus conducting the blast safely through the crude ore,¶ or he shuts off the blast and inserts through the tuyère-pipe a tube just into the ore. The inside pressure will then blow out most of the ore, and this can be helped by working the tube. Lang further advises to use overhead trolleys as much as possible, and advocates the erecting of smelting works on a horizontal plane, instead of one that is inclined.

One source of lead poisoning is effectively removed at the Tarnowitz Smelting

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* *S. M. Q.*, XV., 109.
† *Pr. Z.*, XLI., 282; *B. & H. Ztg.*, 1894, p. 299.
‡ *E. & M. J.*, Dec. 30, 1893; Jan. 20, 1894.
§ *Ibid.*, Feb. 3, 1894.
‖ *Ibid.*, Oct. 14, 1893.
¶ Mentioned also by BARTLETT: *E. & M. J.*, Feb. 8, 1890.

Works* by tapping the lead from the well of the blast furnace directly into molds fastened to a link belt, instead of into an iron pot and then ladling it. The link belt is set in motion by turning a crank at the farther end, and the bars, when solidified, are dropped on to a carriage passing under the frame of the belt.

Terhune† describes the plant which he built at the Hanauer Smelting Works, Salt Lake City, Utah, for granulating slag. It is a wooden trough 2 ft. wide and 6 in. deep, inside measurements, the bottom of which is covered with 1-in. cast-iron plates. It is placed underground 10 ft. in advance of the front of the furnace building and parallel with it. The pitch is ¼ in. to the foot. This was found to be the one best suited to the limited amount of water available, with a 13-ft. head, to granulate and carry away the slag from four furnaces discharging from the tapping-pots into the trough in streams of 1¼ in. Near the face of the dump are the chutes, one to each furnace, for discharging the slag into the trough. They are covered by flanged cast-iron plates. It was found that if the depth of the chute exceeded 3 ft. the slag solidified on the bottom of the trough. Any particles of matte carried off by the slag are easily detected by the explosions which they cause when they come into contact with the water. The slag is carried through the trough to a water-tight elevator pit, which is 8 ft. deep and 133 ft. away from the last furnace. It is then raised 40 ft. by a rubber bucket elevator into a storage bin large enough to hold the slag produced in twelve hours, say 100 tons. The belt is 8-ply and 8 in. wide, and the buckets are of malleable iron; the speed of the belt is 250 ft. per minute. The slag-granules are small enough to pass a ¼-in. sieve; whatever parts they strike will be quickly worn out if not protected by iron plates.

Stallman patented‡ a contrivance for granulating slag. It consists of a slag-trough discharging molten slag into a basin and a pipe (with flat discharging nozzle) placed at an angle to the line of the trough, discharging water under pressure against the stream of slag which is removed at intervals from the basin, the water flowing off continuously. Longmaid§ says that the granulating of slag at Clifton, Ariz., was caused by following the advice of Raht, given many years before under different circumstances. Colquhoun‖ contradicts this, saying that the granulating was based on the practice of the Anaconda Copper Works in 1888, and has since been modified to suit the conditions at his works.

Matte.—Some interesting facts regarding the constitution of iron matte are published by Farbaki¶ in a paper on the matting of silver and gold-bearing pyritic ores at Zalatna, Hungary. They uphold the statement made by Münster in 1877 that the excess of iron found in matte over the amount required to form iron sulphide, FeS, is owing to the presence of metallic iron, which is held in solution by the liquid matte and crystallizes out upon cooling. At the works flattened pieces of metallic iron of varying size are found in the ball mill when the crude blast-furnace matte is being crushed. Also, in treating it with sulphuric acid to dissolve the copper and to generate hydrogen sulphide, only hydrogen is de-

* *Pr. Z.*, XLI., p. 281; *B. & H. Ztg.*, 1894, p. 299.
† *S. M. Q.*, XV., 108.
‡ Patent No. 512,761, Jan. 16, 1894.
§ *E. & M. J.*, Jan. 27, 1894.
‖ *Ibid.*, Feb. 17, 1894.
¶ *B. & H. Ztg.*, 1894, p. 184.

veloped toward the end of the operation. This led to analyses being made of the matte which was removed in thin slabs from the two brasque fore-hearths, No. 1 overflowing into No. 2, into the first of which it had been tapped.

No. of Sample.	Matte Taken.				Elementary Analysis.					Rational Analysis.	
	From Hearth No.	At a Depth of, Inches.	Thickness of, Inches.	Specific Gravity.	S %.	Fe %.	Cu %.	Ag, oz. per Ton	Au, oz. per Ton	FeS %.	Fe %.
1	1	Top	¾	4.807	31.42	65.98	0.23	8.98	3.44	86.40	11.00
2	1 & 2	3⅞	1⅜	5.092	31.18	66 77	0.25	9.04	3.50	85.78	12.55
3	1 & 2	10¼ Bottom	1⅛	5.209	29.55	68.27	0.25	7.87	5.25	81.25	16.57
4	Average 1879–1889.....				29.30	65.10	0.49	.....	.....	78.86	14.92

The tabulated analyses show that there is a large amount of metallic iron present, which sinks slowly through the matte and collects at the bottom, carrying gold with it. This last fact is strikingly illustrated by the results obtained in working up by itself a hearth accretion in which 80% of the precious metal was found to be gold.

Neill* records two experiments with the magnet for separating the shots of matte so often found inclosed in the slag shells; the matte being attracted by the magnet and not the slag† as long as its ferrous oxide does not exceed 34%. In the first instance a sample of the shell from the top of the pot, crushed through an 80-mesh sieve and assaying 12.1 oz. silver per ton, gave magnetic material assaying 48.4 oz. (equal to 64.4% of the silver contained in the slag) and non-magnetic material assaying 5.5 oz. In the second instance, the slag from a copper-matte concentration assaying 5.8 oz. silver per ton gave magnetic material assaying 36.7 oz. (equal to 38% of the silver contained in the slag) and non-magnetic material assaying 3.2 oz. On the different magnetic behavior of matte and slag he bases his improved slag-pot referred to in THE MINERAL INDUSTRY, Vol. II., p. 437.

Nesmith patented‡ an oblong furnace with cast-iron jackets having the usual boshes. Instead of standing on the hearth walls their lower part replaces these, the bottom of the crucible being formed by a heavy flanged cast-iron plate which encloses the lower ends of the jackets, and is supported by jack-screws. Walker and Murphy§ have a method for heating the blast in connection with a circular water-jacket copper furnace which may prove of use to lead smelters. They surround the crucible of the furnace with an air-jacket, introduce the blast near the one upright partition, drawing it off from above on the opposite side into the usual wind-box. The advantages obtained at the works of the Old Dominion Company, of Globe, Ariz., were the longer life of the crucible, the saving of 6 lbs. of coke on 500 lbs. of ore by the raising of the temperature of the blast 46° C., and the greater comfort of the furnace men.

Iles‖ separates the mixture of matte and slag produced in concentrating matte in the blast furnace by collecting it in an external crucible, running off the slag

* *Tr. A. I. M. E.*, XXII., p. 677.
† See NEILL: *Ibid.*, XX., p. 580.
‡ Patent No. 512,053, Jan. 2, 1894.
§ *E. & M. J.*, Dec. 16, 1893; *B. & H. Ztg.*, 1894, p. 101.
‖ Patent No. 515,081, Feb. 20, 1894.

at the surface at right angles to the direction in which it entered it, while the matte is tapped at the lower opposite side. He also recovers* metal from matte-bearing slag by feeding scrap iron into the melted mass kept at a high heat in a reverberatory furnace. Lang patented† a process for treating matte or speise containing gold, silver, cobalt, and nickel, the details of which are not clear.

Cohen‡ describes the negative results obtained at the lead and zinc smelting works of Stolberg, near Aix-la-Chapelle, Prussia, to extract by electrolysis the copper from lead matte containing from 15% to 16% copper, 14% lead, and 14.58 oz. silver per ton, the processes used being those of Marchese§ and of Siemens and Halske.‖ With the former the non-success was owing to the accumulation of sulphur at the anode, the crumbling of the matte anode which caused short circuiting, and finally the polarization which demanded a current of high electromotive force. With the Siemens and Halske process there was also a failure because of the disintegrating and crumbling of the carbon anodes, which falling perforated the diaphragm that separates the anode and cathode. This necessitated an increase in the strength of the current. Siemens and Halske¶ say that the unsuccessful experiments referred to by Cohen took place in 1888, before they had perfected their process.

Slag.—Howell and Ashcroft (see THE MINERAL INDUSTRY, Vol. II, p. 439) describe** the experiments they made at Broken Hills, Australia, to utilize the waste heat of lead blast-furnace slags for generating steam. The apparatus finally adopted by them consists of a horizontal shell boiler through which pass slightly conical vertical tubes which are closed at the bottom by trap doors. The slag is brought from the blast furnace in ordinary slag-pots to the top of the boiler and poured into the tubes. When it has cooled somewhat, it is discharged into wrought-iron cars, where it gives up the rest of its heat to the feed water of the boiler, which is passed through it before it goes to the dump. The hot slag-shells, which are apt to be rich in metal, are dumped into sheet-iron brick-lined bins placed at either end of the boiler, whose heat they thus serve to sustain. In this way a furnace 112 in. by 60 in. furnishes more steam than is necessary to run its plant.

Flue Dust.—A most excellent paper by Saeger on the contrivances in use at the Tarnowitz Smelting Works, Prussia, to collect dust and fumes from furnaces, is published in *Pr. Z.*, XLI., p. 267, abstracted in *B. & H. Ztg.*, 1894, p. 299. While its main object is to show the effect that they have had on the workmen, the well-illustrated descriptions of the apparatus and the discussions about the quantities of flue dust formed and saved would make it, even if the sanitary side were omitted altogether, a most valuable technical contribution. The improvements consist in drawing off the fumes from reverberatory and blast furnaces, in cooling the gases by passing them through water towers and Monier flues, in settling out the fine particles by the Roesing wire system, and finally in filtering

* Patent No. 515,082, Feb. 20, 1894.
† Patent No. 519,129, May 1, 1894.
‡ *Z. E. & E.*, 1894, p. 50; *O. Z.*, 1894, p. 432; *Ch. Ztg.*, 1894, p. 488; *B. & H. Ztg.*, 1894, p. 328.
§ See *Scientific American Supplement*, Nos. 478 and 479.
‖ See *E. & M. J.*, March 19, 1892.
¶ *O. Z.*, 1894, p. 494.
** *E. & M. J.*, July 21, 1894.

to recover the last particles of lead and silver. The great difference between the temperatures on the outside and the inside of the Monier flues has caused the cement to crack in several instances. The new flues are to be built in sections $6\frac{1}{2}$ ft. long, with open joints $\frac{1}{32}$ in. wide, to be covered by flat strips. This will allow the flue to expand and contract freely, and is expected to prevent the cracking. The cooling of gases has been very effectively accomplished at some works in this country with dust flues of corrugated iron which is nailed on to a wooden frame, the joints between wood and iron being made air-tight with asbestos boards, and those between iron and iron with red lead. To save the handling of the flue dust, the bottom of the flue is V-shaped. It has been suggested to suspend screens longitudinally in such flues, which would offer greater surfaces than Freudenberg plates.

The Roesing wire system for condensing flue dust consists (see Figs. 9 to 11) of

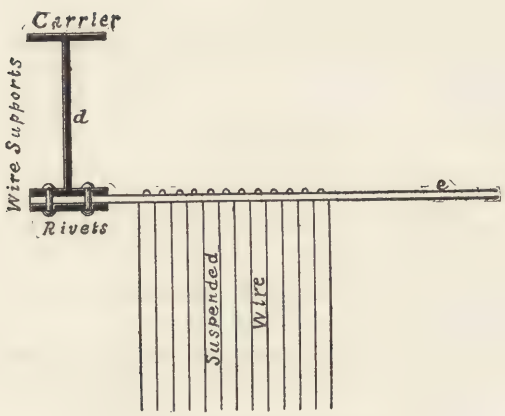

FIG. 9.—VERTICAL SECTION.

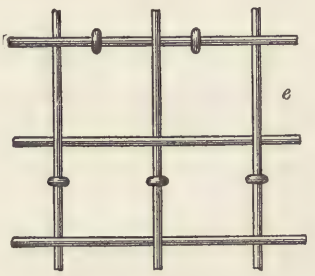

FIG. 10.—PLAN.

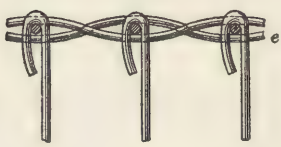

FIG. 11.—ELEVATION.

a great many wires of No. 10 gauge and 10 ft. long, suspended from a wire screen, *e*, of about 1 in. mesh, which is riveted to I-beams, *d*, running along the top of the flue, $16\frac{1}{2}$ ft. high. In 1888, during 300 working days, there passed off into the open air with the old system 121,000 lbs. of solid matter for every furnace, while with the wire system the weight of the solid matter was reduced to 90,200 lbs. without diminishing the draught of the chimney.

According to a note in the *M. S. P.* of Nov. 17, 1894, the Omaha and Grant Smelting and Refining Company of Omaha, Neb., have introduced the system of filtering for saving the flue dust from their blast-furnaces, refining and cupelling furnaces.

Chanute and Iles* divide the dust chamber at the back of the blast furnace into two parts by an inclined plate. The flue dust collects in the upper chamber and is cooled by a current of air passing through the lower one. Gale patented† an apparatus intended to separate and collect the dust from a current of air.

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* Patent No. 515,071, Feb. 20, 1894. † Patent No. 516,371, March 13, 1894.

F. L. Bartlett patented* a process and apparatus for agglomerating and in part desulphurizing finely divided ore, matte, flue dust, etc. For this purpose he mixes the ore with slack of coking coal, heats the mixture to drive off and burn the volatile hydro-carbons and fuse the residue into coke, which serves to cement the ore. The furnace is similar to the one used for making zinc white from franklinite and oxide zinc ores. It consists of an arched oblong chamber divided by a grate or a series of perforated iron plates into two parts. The charge is placed in the red-hot upper chamber on the grate, blast is introduced from beneath, and the products of combustion are drawn off through an opening in the roof leading into a flue common to a series of furnaces and ending in a dust chamber. The coke-like residue from the process is charged into a blast furnace, either alone or with the regular ore charge. Sanders† proposes as a practical method for agglomerating fine iron ore to mix it with finely divided slag and heat the mixture.

DISILVERIZATION OF BASE BULLION.

Electrolysis.—Borchers describes‡ with illustrations his apparatus and method for electrolyzing bismuth-bearing lead. He frees the lead from the bismuth down to a trace, recovering it as an alloy containing from 90% to 95% bismuth and from 10% to 5% lead. He uses a cast-iron pot which consists of two half-cylinders laid horizontally end to end and joined by a water-cooled cast-iron flange having the form of an inverted T. This keeps the liquid metals in the bottom of the pot separate, and the metallic contact being prevented by a clay, sand, or marl, the anode is isolated from the cathode. On the side of the anode the cylinder is closed by an inwardly inclined plane having a series of troughs over which the metal when poured in at the top runs down slowly, on the side of the cathode, by a vertical plane. The metals collecting at the bottom are discharged through separate pipes. The pot is enclosed by brick-work and heated from a lateral fireplace. In operating, the pot is first warmed, melted lead is poured in through the discharge-pipes until it almost reaches the top of the flange, melted alkali—and alkali earth—chlorides are added, and when the pot is nearly filled some lead oxide which is to neutralize any chlorine that is set free; the current is started and melted bismuth-bearing lead fed in at the top of the anode side. While running down from trough to trough the lead is dissolved by the melted chlorides and deposited at the cathode, while the bismuth—also any silver that is present—is not acted upon and collects in the anode pocket. The loss in alkali chloride has to be made up at intervals. A current of 1000 ampères per square meter and of 0.5 volts deposits 4.5 kilogrammes lead per metric horse-power per hour.

Parkes Process.—Meisel§ describes his apparatus for uniformly moistening with from 5% to 7% of water finely pulverized clay. It seems also to be well-adapted for the moistening of the brasque, marl, and cement used in the bottoms of softening, refining, and cupelling furnaces, and consists of a shallow iron cylinder closed at the lower end by a screen suspended from two rods that cause it to

* Patent No. 512,531, Jan. 9, 1894.
† Patent No. 516,710, March 20, 1894.
‡ *Z. E. & E.*, I., p. 13.
§ *T. I. Z.*, 1894, p. 298.

oscillate up and down. Through the center passes a hollow revolving shaft having four horizontal arms which turn over the clay fed on to the screen. A water-pipe ending in an atomizer passes down through the hollow shaft. The dry clay fed into the cylinder is stirred up by the revolving arms, sifted through the screen, and then met by a finely divided spray from below. In this way an intimate mixture of clay and water is insured.

At Tarnowitz, Prussia, the new desilverizing kettles, holding thirteen tons of argentiferous lead, are made of crucible steel.* The retort bullion, which is poor in silver on account of the low-grade character of the base bullion, viz.: 13.1 oz. silver per ton, is desilverized a second time, the resulting zinc crust furnishing a retort bullion with about 1700 oz. silver per ton to be cupelled. The paper contains also a good detail drawing of Roesing's lead-pump, and a description of the manner of using it.

Petraeus† proposes to improve on the usual methods of treating zinc crust by smelting it in such a way as to volatilize and oxidize all the zinc and then collect it by filtering, and in a similar manner to recover oxide fumes from refining desilverized lead.

Cupellation.—Asbeck,‡ describing the treatment of argentiferous lead ores at Sala, Sweden, mentions an interesting experiment in reducing litharge as it flows from the cupelling furnace, the results of which were very promising. An iron pipe about 4 in. in diameter and 1 ft. 7¾ in. in length, filled with small pieces of glowing charcoal, was placed on a grate in front of the furnace and the litharge made to run into it. It was completely reduced by the incandescent carbon with little loss of metal, the small amount of fume produced being conducted into the dust chamber. It will be remembered that Roesing§ suggests a similar method to reduce the litharge formed in his proposed bessemerizing of argentiferous lead.

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* *Pr. Z.*, XLI., p. 268; *B. & H. Ztg.*, 1894, p. 299.
† Patent No. 515,164, Feb. 20, 1894.
‡ *B. H. & Ztg.*, 1893, p. 439.
§ *E. & M. J.*, April 16,18 92.

THE FUTURE OF THE BROKEN HILL SILVER-LEAD MINES.

As there have been many speculations about the future of the Broken Hill mines—at present the largest silver-lead producer in the world—it has been considered of interest to present here the estimate made by Mr. John Howell, the manager of the Broken Hill Proprietary Company, and published in the report of that company for the half-year ending Nov. 30, 1894:

"It is quite evident that the sulphide ores of the Proprietary mine cannot possibly be successfully and profitably reduced, alone, by direct treatment in blast furnaces. A preliminary dressing and concentrating will have to be resorted to, to rid the sulphides of a portion of their zinc, silica and other objectionable ingredients before they can with success be subjected to a heat-reducing process. This preliminary dressing and concentrating can, and no doubt will, be done on the Barrier, but the smelting of the concentrated material, which will require a good deal of fuel and manipulation, will have to be carried out at the seaboard, where fuel, labor, limestone, iron, and other important requisites are cheaper than at Broken Hill.

"During the half-year we have treated several lots of the sulphide ores by concentration in an experimental plant erected for that purpose, and the results were favorable. We obtained, on an average, from a little over three tons of crude sulphide ore, one ton of concentrated material, which gave an assay value of from 50% to 65% of lead, from 20 to 28 oz. of silver, and from 6% to 8½% of zinc per ton. A large quantity of this concentrated material could be successfully reduced, without desulphurization or any other preliminary treatment, directly in our smelters in combination with our dry siliceous oxidized ores, but if the concentrated sulphides had to be treated alone they would have to be subjected to a desulphurizing and oxidizing treatment in reverberatory or other suitable furnaces before they could be successfully reduced in blast furnaces. At present we are smelting from 800 to 1000 tons of crude sulphides per week, blended with our oxidized ores. The new concentrating plant erected during the past half year has been designed, one-half for the treatment of oxidized and carbonate ores, and the other for sulphides.

"In a special report published with my ordinary report for the half-year ending May 31, 1892, I gave, after very careful investigation, as an estimate of the quantity of ore remaining in the mine at that time, 2,000,000 tons of payable oxidized smelting ores. Two and a half years have since elapsed, and we have mined and treated during that period about 1,280,000 tons. We have, however, within the time mentioned, discovered two isolated bodies of ore which, at the time of the preparation of the estimate, were not known to exist, so that it is safe to say we have yet about 1,000,000 tons of payable oxidized ores left in the mine of a character and value suitable for direct treatment in the principal metallurgical works. Besides this, we have a large quantity of concentrating ore, which can be reduced to a profitable smelting ore, and these quantities, together with the concentrated sulphides that will be obtained from the new concentrating plant, enable us safely to say that we have remaining in the mine at the present time sufficient oxidized ores (with what sulphide concentrates can be produced) to keep all our metallurgical plants running, at the rate we are now working, for two years.

MAGNESITE.

MAGNESITE, or magnesium carbonate, corresponds chemically to calcium carbonate; it has the chemical formula $MgCO_3$ and is found in many parts of the world, usually occurring in nearly pure form, the most common impurities being ferrous oxide and silica. It is usually found in association with some of the magnesian rocks, such as serpentine or talcose schist.

Until within a few years it was used chiefly as raw material in the preparation of the various magnesium salts, while a small quantity has been employed as a bleaching agent in the manufacture of paper from wood pulp. Recently, however, it has been found that magnesite is an excellent refractory material, and that, especially for hearths of basic steel furnaces, it is superior to anything previously employed. This has increased the demand largely.

The deposits of magnesite which yield the principal commercial supply at the present time are those of Styria in Austria, of Silesia, of Greece, and, in our own country, of California.

Austria.—The Austrian deposits, formerly regarded as the most important, are found at Veitsch in Styria. The mineral is here found in beds comformable with the strata and is usually seamed with small stringers of quartz, dolomite and calcite, so that it is found necessary to break and clean it before calcining. The clean mineral contains from 90% to 96% of magnesium carbonate. It is calcined at white heat, then carefully picked and sorted, crushed and made into bricks which are then burned in large kilns. The manufacture of bricks was first begun in 1890, and has proved very successful. The greater part of the magnesite taken out at Veitsch is utilized in this way.

Notwithstanding the early establishment of the works there and the command of the market which was thus secured the production is not increasing. In 1891 the total reported was 5330 tons of raw magnesite and 8310 tons of the calcined mineral. In 1892 the output was 3690 tons of raw and 9020 tons of calcined, and in 1893 it was slightly less.

Magnesite is also found in Moravia, but is not mined there to any extent.

Germany.—In Germany magnesite is found at Grochau and Baumgarten near Frankenstein in Silesia. Both deposits are owned and operated by a company known as the Deutsche Magnesit Werke, which has works at Frankenstein where the mineral is calcined and made into bricks. The annual production

for several years past has been from 5500 to 6000 tons of the crude mineral. Besides refractory bricks for furnaces, these works also make tiles and slabs for roofing, flooring, lining and other building purposes. Its use in this direction is extending, especially in so-called fireproof construction.

Greece.—The magnesite deposits in this country are in the northern part of the Island of Eubœa. The mineral is here found in large veins in serpentine, and is more nearly pure than in any other of the European deposits. The working of these deposits was begun many years ago, but in 1888 the production was only about 300 tons. Some years ago, however, the mines passed into the hands of a French company which established large works for the manufacture of brick, and since then the output has increased very rapidly. In 1893 it was reported at 8815 metric tons of crude mineral, and in 1894 at 13,262 tons.

United States.—In this country magnesite has been found in the East, in Massachusetts, New York, Maryland and Pennsylvania, but nowhere in sufficient quantity or purity to warrant its working. It has been found in Arizona, but the extent of the deposits there has not been determined; also in Texas, where large deposits are reported. In California it has been found in large quantities at several localities in the foothills of the Sierra Nevadas. The most important are at Cedar Mountain and Livermore in Alameda County; at Gold Run and Iowa Hill in Placer County; at Arroyo Seco in Monterey County, and at several points in Mariposa, Tuolumne, Santa Clara and Napa Counties. It has also been found in lumps or nodules in the quicksilver mines at Sulphur Creek in Colusa County. The most important deposit at the present time is at Child's Valley, near Rutherford in Napa County, and it is from this that the American supply of magnesite is now drawn.

The following table gives the production of this mineral in California for the years from 1891 to 1894 inclusive; prior to 1891 it was not mined on a commercial scale. The mineral taken out at Child's Valley is hand-picked to free it from gangue and impurities, and is calcined before shipping. For several years past the larger part of the output has been shipped to Oregon, where it is used in the manufacture of wood pulp for paper.

PRODUCTION OF MAGNESITE IN CALIFORNIA.

Year.	Crude.		Calcined.		Crude Equivalent of Calcined, Short Tons.	Total Crude.	
	Amount, Short Tons.	Value at Mine.	Amount, Short Tons.	Value at Works.		Amount, Short Tons.	Value.
1891.....	117	$819	322	$6,440	644	761	$5,397
1892.....	608	4,256	397	7,940	794	1,402	9,814
1893.....	263	1,841	440	8,800	880	1,143	8,000
1894.....	450	1,600	460	6,500	920	1,370	4,864

Other Countries.—Magnesite has been found in Canada in the eastern townships of Quebec, and examinations were made of deposits at Bolton and Sutton by the Geological Survey. So far as known these deposits contain a higher proportion of iron oxide than is desirable.

In Russia deposits of magnesite are known to exist on the Asiatic slope of the Oural Mountains, but have never been worked to any extent.

MANGANESE.

In 1891 the production of manganese ore in the United States was 22,437 long tons, the highest point yet reached. In 1893 the production fell off to 9,582 tons. In 1894 there was a slight recovery, the production rising to 11,735 tons, an increase of about 24% over the preceeding year. The decrease shown in 1893 and 1894 was due, in part, to the smaller demand from the steel trade, and in part to the cheapness and facility with which manganese ores can be imported. It is usually possible to deliver the foreign ores at any point on the Atlantic seaboard at a lower cost of transportation than from the American mines. The average consumption of manganese ores in the United States was estimated in 1893 at from 70,000 to 75,000 tons annually. In 1894 the chief consumer of these ores reported a total of 52,737 tons, so that the decrease in consumption was large.

The increase in output in 1894 over the preceeding year was quite evenly distributed. The production in Arkansas increased from 2000 to 3060 tons, the last named figure, however, being less than half of that for 1892, when 6708 tons were reported. The mines in that State are in the northern part, near Batesville, and no new discoveries were reported during the year.

The Colorado production comes from a few mines in the Leadville district and showed a gain not only over 1893 but also over 1892. The manganese ore produced in that State, however, may be regarded as a by-product, the mines being worked chiefly for other minerals. It will be noted that last year this State furnished nearly 45% of the total production of the United States.

In Georgia the production in 1894 was double that of 1893, but considerably less than that of 1892. The manganese ore mined in this State comes from a few mines in Bartow County, in the northwestern part of the State, and the opening or shutting down of one mine will make a large difference in the production.

The Virginia output in 1894 remained about the same as in 1893. It has not been large since the Crimora mine closed down early in 1893; that mine was the largest producer, and there was no other to take its place.

Tennessee appears in the list of producers in 1894 with an output of 921 tons. The small quantity reported from California shows but little change. West Virginia reports for the first time some manganese ore, only 66 tons, however,

being the amount of its production. The following table shows the production of manganese ore in the United States for the five years from 1890 to 1894; the statistics for the years prior to 1890 will be found in THE MINERAL INDUSTRY, Vols. I. and II.

MANGANESE ORE INDUSTRY IN THE UNITED STATES.
(In tons of 2240 lbs.)

Year.	Production.									Imports.*		Consumption.	
	Arkansas.	California.	Colorado.	Georgia	Tennessee.	Virginia.	West Virginia.	Total	Value.	Tons.	Value.	Tons.	Value.
1890..	5,339	.....	.....	749	.....	12,699	.....	18,787	$158,585	33,998	$509,704	52,785	$668,289
1891..	1,650	.....	964	3,575	.....	16,248	.....	22,437	191,613	28,624	371,594	51,061	563,207
1892..	6,708	150	4,000	2,000	.....	6,079	.....	18,937	154,582	58,364	830,046	77,301	984,628
1893..	2,000	450	4,700	500	.....	1,500	.....	9,150	60,000	67,717	860,832	76,867	920,832
1894..	3,060	250	5,000	1,000	921	1,438	66	11,735	74,890	.....	.....	.....	.....

During 1894 the largest quantity of manganese ore imported was from Russia, that country furnishing nearly two-thirds of the total imports; of the remaining third about one-half came from Japan and the remainder from Chile and Cuba. Since the close of the year there has been a large increase in the amount sent from Cuba to this country for reasons explained below. It is understood, also, that there will be a large supply in the future from Central America, where some important deposits are known and will shortly be worked on a large scale.

The principal use to which manganese ore is put in this country is in the manufacture of ferro-manganese, the application of which in making Bessemer steel is well known. Some ferro-manganese is made from ores found in connection with the zinc ores of Sussex County in New Jersey, but the principal manufacturer in this country is the Carnegie Steel Company, which not only supplies its own wants but has a considerable surplus for export. Manganese ores are also used in the chemical industry, but to a smaller amount than formerly.

The Carnegie Steel Company, which is the principal user of these ores, reports its prices for domestic ores as below; the schedule remained unchanged during 1894. The prices are based on ores containing not more than 8% silica and 0.10% phosphorus, and special reductions are made of 15c. per ton for each 1% of silica in excess of 8%, and of 1c. per unit of manganese for each 0.02% phosphorus in excess of 0.1%. Settlements are based on analyses made of a sample dried at 212°, the percentage of moisture in sample being deducted from the ore.

Manganese.	Prices Per Unit.
Ore containing above.....49.00%	Iron.....6c.—Manganese.....28c.
Ore containing.....46.00% to 49.00%	Iron.....6c.—Manganese.....27c.
Ore containing.....43.00% to 46.00%	Iron.....6c.—Manganese.....26c.
Ore containing.....40.00% to 43.00%	Iron.....6c.—Manganese.....25c.

This company received during the year 52,737 tons of manganese ore, of which 5956 tons were native and 46,781 tons imported ores. The imported ores were drawn from the following countries: Cuba, 2199 tons; Chile, 5780 tons; Japan, 6444 tons; Russia, 32,358 tons.

The following table shows the manganese ore production of the world for the five years from 1890 to 1894, inclusive. The statistics for the years prior to 1890 will be found in THE MINERAL INDUSTRY, Vols. I. and II.:

Year.	Austria-Hungary.	Belgium. (*a*)	Bosnia.	Canada.	Chile.	Cuba.	France.	Germany.	Greece.
1890.....	9,452	14,255	5,500	1,205	48,759	22,161	15,984	41,841	13,547
1891.....	5,409	18,498	8,847	231	35,017	22,341	15,343	40,335	13,453
1892.....	5,868	16,775	7,944	104	50,000	18,000	32,406	32,861	11,716
1893.....	5,411	.....	7,403	193	50,000	13,922	38,080	40,798	5,250
1894.....	.....	.....	.....	67	.....	.....	.....	43,702	9,319

Year.	Italy.	Japan.	New Zealand.	Russia.	South Australia	Spain.	Sweden.	United Kingdom.	United States.
1890.....	2,147	2,612	490	182,468	2,808	9,872	10,698	12,643	19,094
1891.....	2,429	3,249	1,172	113,090	861	6,993	9,079	9,628	22,757
1892.....	1,243	5,027	529	199,195	715	16,910	7,832	6,175	19,247
1893.....	810	14,169	324	*b*225,000	.....	14,600	7,061	1,357	9,297
1894.....	.....	.....	.....	*b*275,000	.....	.....	.....	.....	11,927

(*a*) Ferro-manganese. (*b*) Partly estimated.

Below are given some notes with regard to recent developments in other countries.

Canada.—Some activity has been reported in prospecting for manganese ores in Nova Scotia and New Brunswick, but no important discoveries have been made nor has the output of those provinces been increased. The manganese ore from Nova Scotia is shipped chiefly to England. It was formerly much more considerable than at present, but never reached a large amount.

Chile.—The manganese deposits of Chile continue to be worked on a considerable scale in spite of the fact that they are situated at some distance from railroad transportation and are therefore burdened by heavy freight charges. Most of the ores produced are sent to Europe.

Cuba.—A report from Mr. P. F. Hyatt, United States Consul at Santiago de Cuba, states that the manganese mines of that island, as far as they have been explored, are found in the mountain range between Santiago de Cuba and Manzanillo, extending over a distance of 75 miles. The ore is abundant but the richer deposits are not yet available, owing to the lack of railroad facilities to carry the ore to the seaport. The Ponupo Mining Company, however, is now completing an extension of the Sabinilla & Moroto Railroad to its mines, and as soon as this extension is finished will open up those mines on an extensive scale, shipping the ore in large quantities. Beyond the Ponupo mines in the mountains other large deposits are known to exist.

Some mines near the coast have been furnishing a considerable quantity of ore, which is carried down by mules. These deposits, however, are chiefly small pockets which soon become exhausted. Most of the shipments heretofore made have been from these small mines. During 1892 there was shipped to the United States from the consular district of Santiago de Cuba, 18,851 tons of manganese ore, and during the first six months of 1893 the amount was 11,640 tons. In the latter half of 1893 and in the first part of 1894 the shipments were light, partly owing to the trade depression and the decreased demand from the

United States, and partly to the exhaustion of the small mines above referred to. The railroad to the Ponupo mines was completed early in 1895 and the company is becoming a large shipper.

Europe.—In Europe the mines of Cabesses in France continue to be actively worked and the operations of the company are being gradually extended. The production is still insufficient to supply even the home demand, and a considerable amount is imported. In Spain manganese ores and manganiferous iron ores are mined, and considerable quantities of the former are shipped from Cartagena and other ports. The mines of Laurium in Greece have furnished a considerable quantity of manganese ore but the supply from this source is somewhat on the decrease. Some ore is also brought from Sweden and Turkey.

Russia.—The largest and richest mines are found in the Caucasus. The district of Sharopansk, which is an important one, has recently been connected by a branch line with the Trans-Caucasian Railroad, decreasing the cost of transportation of the ore, and the result has been a larger production and larger exports.

The following recent information concerning the manganese deposits of the Caucasus is compiled from Russian publications of recent date. The most important occurrences of manganese ore are in the governments of Kutais, Tiflis and Telisavetpol, and also in the vicinity of Baku. The ore is found in veins, often in pockets or masses, and frequently mixed with the gangue. An important exception to this rule, however, is found in the large deposits in the district of Sharopansk, in the government of Kutais. The ore found here is in the upper and lower tertiary basins along the Quirilla River, a tributary of the Rion, where it exists in distinctly stratified form. The workings near Chiatur, from which a large quantity has been taken, are on the upper basin. The average height of the basin is 600 meters above the level of the sea. This bed was discovered as long ago as 1848, by the geologist Abich. The Quirilla River at this point has cut a deep bed and flows between steep bluffs from 150 to 200 meters in height, consisting of tertiary deposits on which the manganese ore lies. The strata are only slightly inclined and vary from 1.5 to 2.5 meters in thickness. In a mineralogical sense the principal constituent of the ore body is wad, but pyrolusite, manganite and psilomelane are found in considerable quantities, in the order in which the names are given. The best ores contain as high as 86% of manganese peroxide with from 1% to 2½% of protoxide.

The export of manganese ore from the Caucasus, which began in 1879 with 600 tons, amounted in 1894 to over 250,000 tons, and it is expected that in a few years the total will reach 1,000,000 tons. The average contents of the ore exported was 50% metal, or higher than the average of the Spanish ores.

Other Countries.—Manganese ores are found in many other countries, but no others than those mentioned furnish a commercial supply. In Australia these ores have been discovered in several localities, but have never been worked to any extent, owing to the absence of local demand and the cost of shipping to Europe or America.

While manganese ores or manganese oxides are an important article of commerce, the metal itself is seldom produced in pure form, and must be classed among the rarer elements.

MICA.

THIS name is in a general sense given to several minerals which are similar in their physical characteristics and are distinguished chiefly by their color. In composition the micas are complex silicates of alumina, with other bases, chiefly potash, magnesia, iron and soda. The varieties of commercial importance are three in number, white mica or muscovite, amber mica or phlogopite, and black mica or biotite. The last-named variety is of the least frequent occurrence and of the least importance. Mica is found chiefly in the older rocks, like those of the Appalachian Range in the United States, and of northern Quebec and Ontario in Canada.

The subject of mica, its geological occurrence and other peculiarities, and its uses, has been very fully treated in Vols. I. and II. of THE MINERAL INDUSTRY.

The following table shows the approximate production of mica in the United States in 1893 and 1894:

MICA PRODUCTION OF THE UNITED STATES.

States.	1893.				1894.			
	Ground.		Sheet.		Ground.		Sheet.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
New Hampshire	212,000	$10,522	6,000	$5,478	252,500	$10,957	8,000	$8,728
North Carolina	467,000	19,000	500	500	577,000	25,000	1,900	2,375
Total	679,000	$29,522	6,500	$5,978	829,500	$35,957	9,900	$11,103

The production showed some increase during 1894, in spite of unfavorable trade conditions. The decreased demand for sheet mica in the stove trade, owing to changes in patterns and fashions, has been more than made up by the growing demand for the mineral for electric purposes. This has also caused some variation in the quality of mica required. In the stove trade the clear, light-colored or white mica is most valuable, while in electric work the chief requirements are that the mica must be free from cracks and wrinkles, must split readily and be flexible; it must also be able to stand a high temperature.

There has been a very large increase in the applications of ground mica, and

the preparation of the mineral in that form is increasing. The waste from the mines and dressing works is available for this purpose.

In Canada the mines in the counties of Perth and Renfrew in Ontario and of Ottawa in Quebec have continued steadily at work, and something has also been done at the deposits along the lower St. Lawrence.

In the United States the chief supply comes from the mines of New Hampshire and North Carolina. In New Hampshire some new mines have been opened, and work has been prosecuted steadily at most of the older ones. The North Carolina mines continue to be a reliable source of supply of mica of very good quality.

Mica has been found in other States besides those named, but nowhere else in sufficient quantity or in sheets of sufficient size to be commercially valuable. Small quantities of the mineral are of frequent occurrence in the granitic rocks of the northern part of Westchester County, New York, and in eastern Connecticut, but it is invariably found in blocks so small and so scattered through the rock that it is practically useless.

No new methods of mining have been introduced. Hand drilling is always used in the mica mines, as it is found that with power drills there is always more liability to break up and injure valuable crystals. In separating the mica from the rock great care has to be taken to prevent injuring the blocks, as the commercial price depends very largely upon the size of the sheets. No marked improvements have been made in the methods of preparing the sheet mica for market, in dressing or splitting. Even with the greatest care and experience in mining and preparation the waste of the mineral is considerable, although this is being reduced as the demand for ground mica increases, and the rejected sheets, blocks and clippings can be used in this way. How important it is to the producers to be able to dispose of their waste in this way may be judged from the fact that experts consider that very good work has been done when the weight of the sheets as ready for market is 10% of that of the block mica taken from the mine; in some cases it is said that not more than 5% is attained. Some improvements have been made by producers, chiefly in the introduction of new mining machinery.

Besides the mica supplies from Canada and the United States a considerable amount is furnished by India, but no other country produces or markets any notable amount of this mineral.

MINERAL PAINTS.

THE products classed under this head include a variety of substances, some of which represent a large production and are extensively used, while others appear in much smaller quantities. In addition to the pigments included in the list below accounts will be found of a number of other coloring substances—chiefly those used in tinting china, glass, etc.—in the article under the head of "Metallic Oxides" in this volume. This last class of colors, however, represents only small quantities. The following table shows the production of mineral paints in the United States for 1893 and 1894:

PRODUCTION OF MINERAL PAINTS IN THE UNITED STATES.

(In tons of 2000 lbs.)

Product.	1893.			1894.		
	Tons.	Value.		Tons.	Value.	
		Total.	Per Ton.		Total.	Per Ton.
Iron oxides	21,312	$228,580	$10.70	19,930	$220,790	$11.00
Ochers	18,862	201,830	10.70	15,287	121,972	8.00
Ultramarine	1,100	220,000	200.00	1,400	280,000	200.00
Umber, sienna and slate	1,600	23,250	14.53	1,200	16,200	13.50
Venetian red	1,835	41,700	22.72	984	23,200	23.67
Vermilion	37	40,000	1,081.08	41	45,600	1,112.19
White lead	88,500	9,469,500	107.00	87,242	8,445,174	96.60
Zinc oxide	25,000	1,875,000	75.00	22,814	1,711,275	75.00
Totals	.....	$12,099,860	.....	.....	$10,864,211	.....

The production of mineral paints suffered to some extent from the business depression during 1894. In one or two exceptional cases there was a small increase in production, but most of the articles named showed some decrease in quantities and also in prices. Notwithstanding the unfavorable condition of business, however, some new factories were started and some improvements introduced in the various trades. A special instance noted is that of a company making iron oxide paint in Georgia from local ores, which increased its plant and is shipping a considerable amount of its product to Europe.

Iron Oxides.—These pigments, also known in the trade as "Natural Reds," are classed as natural and artificial. The former are chiefly made from brown iron ore (hematite) and from ferruginous shales. They are highly esteemed for

some purposes on account of their durability, and especially in certain localities on the seacoast from the fact that on buildings they resist the effect of the salt air better than any other pigment known. The production of iron oxide paints, as will be seen from the table, is larger in amount than that of any other named with the exception of white lead and zinc oxide. The artificial iron oxide pigments are included more properly under the heads of Venetian red and ocher.

Ochers.—Under this head are included clays which have been tinted by ferrous or ferric oxides. They vary in color from a golden yellow to a dark red, and occasionally also present various shades of blue and green. There is a wide variety in the quality and value of the ochers. For many purposes they are extensively used, and they are found in many localities.

Slate Pigment.—This paint is made by grinding slate to a fine powder and mixing it with oil and other colors. It is not yet largely introduced.

Umber and Sienna.—These paint materials are really varieties of ocher, being tinted various shades of brown by the admixture of iron and manganese oxides. The better grades of these paints are imported, although an excellent grade of sienna is made by one manufactory at Bethlehem, Penn.

Venetian Red.—This pigment is obtained by calcining copperas (sulphate of iron) in a reverberatory furnace, the result being ferric oxide in a finely divided condition. This paint is often adulterated with ground iron ore. A description of the methods used will be found in the article on "Metallic Oxides."

Vermilion.—This well-known color is made from metallic mercury, although, if the trade is to be believed, it is difficult to find it in a pure state. A considerable part of that used in this country is imported.

White Lead.—This well-known and universally used pigment is still made largely by the old process of corroding pig lead, although a number of new methods of making a carbonate of lead have been tried and some have been introduced in recent years. Some reference to the methods of manufacture will be found in the article on "Lead." It may be called a staple of prime importance in the paint trade and has for many years been universally used.

White lead is often mixed with barytes. In the United States this mixture is usually regarded as an adulteration, but in Europe it is recognized as a legitimate practice, and for some purposes is thought to improve the paint. The production of white lead last year showed a very slight decrease, amounting only to 1258 tons, or about 1½%; there was, however, a considerable reduction in prices.

Zinc Oxide.—This pigment, also known as zinc white, is usually produced by forcing a current of air through a layer of ground zinc ore mixed with coal on a grate in a low furnace. The oxide passes over with the products of combustion and is collected in muslin bags. In the French process, as used at Florence, Penn., spelter and zinc dross are oxidized by ore passed through a heated retort. Improved processes have been introduced in recent years. For many purposes zinc oxide is a superior pigment and its use in the trade is increasing. The production last year, however, showed a decrease, principally owing to the small demand in the building trades. Like white lead, zinc white is sometimes adulterated with barytes and occasionally with other substances.

MONAZITE.

MONAZITE, a mineral which until a few years ago had no industrial use, and therefore no commercial importance, was first found and received a name some seventy years ago in North Carolina, from which the principal supply is now drawn. In composition it is a phosphate of cerium, lanthanum and thorium, with occasionally other rarer metals of the same group, and the oxides of these metals can easily be separated by proper treatment. It contains some silica and occasionally a little iron oxide, although the last-named diminishes its value.

It was discovered some time ago that the oxides of the metals of the cerium group, especially thorium, possess the property of glowing with very great brilliancy when strongly heated, while at the same time they will resist decomposition at any but the very highest temperature. This attribute is common to all the group, but thorium gives a whiter and more agreeable light than any of the others, and for that reason monazite has a high commercial value, for it is the cheapest and most abundant source of thorium oxide known.

The first use of thorium oxide was made in the Welsbach incandescent gas light, which is now being manufactured on a large scale and has been introduced both in this country and in Europe. These manufacturers are the chief consumers of monazite here and in Europe. As other systems of incandescent burners are being introduced, the use of the mineral will extend.

Geologically, monazite is obtained from the sands due to the disintegration of the gneissic, talcose and metamorphic rocks. Monazite was frequently found years ago in the gold placer washings of western North Carolina and South Carolina, but was regarded as of no value except as a mineral specimen; in some cases it was mistaken for tin ore. The saving of the mineral as a regular industry was due to Mr. Hidden, the well-known mineralogist, who, while looking for platinum in the gold washings near Brindletown, N. C., in 1879, found monazite in considerable quantities and sent some of it to Mr. Edison, who was then working on the incandescent electric light. In this case it proved of no particular value, but five years later, in 1884, Mr. Hidden, while searching in the same region for zircon, secured some 25 tons of monazite for the Welsbach Light Company, and persuaded that company to experiment with it. The result of the tests was the discovery that the thorium oxide obtained from monazite was a better material than zircon, since the thorium lasted longer and was free from the tendency to

crack or break while cooling. The quantity required for a single burner is so small that the total consumption is not large; but it has increased very much since its introduction on the German market, about two years ago.

Prior to 1893 the production of monazite was spasmodic. With the first demand such a quantity was saved that it depressed the price, and the output then fell off; now, however, the market takes readily all that can be produced. The highest commercial price on record was in 1887, when it was sold for 25c. per lb. This produced an excessive supply and the price fell off to 4c. or 5c. At the present time the price varies from 6c. per lb. for mineral containing 2%, up to 20c. for mineral having 6% thorium oxide, which is about the highest grade; the average price of monazite in 1894 was between 7c. and 8c. per lb.

The production in 1893 was 130,000 lbs.; in 1894 it increased to 750,000 lbs., while persons familiar with the industry estimate that during the current year the output will exceed 1,000,000 lbs.

In North Carolina the monazite sand occurs among the pebbles, mud, and mineral sands in the old watercourses in deposits up to 2 ft. in depth, and the following method is employed to separate it: The coarser gravel is removed from the fine monazite sand by raking over perforated iron plates 2 ft. square in the running water of the stream; this also removes most of the clay. The sands going through these plates are concentrated by raking back and forth in a sluice-box similar to the old washing buddle. The separation requires considerable care, though, fortunately, magnetic and titanic iron, which are the principal impurities, can be removed by a hand-magnet after drying. The average concentrates contain about 70% monazite sand and must contain over 60% of 2% thoria sand to be marketable.

The deposits are scattered and the exploitation is done by farmers or others who work intermittently. The industry is not large enough to warrant the expenditure of capital required for putting in concentrating machinery.

Monazite has been found in Australia, Brazil, Norway and Siberia, but no competition is to be expected from those countries, as it has not been found elsewhere carrying as high a percentage of thorium oxide as in this country.

Australia.—Some Australian monazite has recently been delivered in Europe for a price as low as 5c. per lb., but no particulars can be obtained as to its occurrence or the extent of the deposits.

Brazil.—Monazite is found on the Island of Alcobaco among the beach sand, the result of the disintegration of the rocks by the waves. It is collected and shipped from the port of Bahia to Liverpool and Hamburg. Shipments have occasionally been made to the United States, but not in large quantities.

Norway.—A small quantity is shipped from Christiania to Germany. The mineral is found in the streams and the quantity saved is unimportant.

Siberia.—Here, as in the United States, some monazite is found in working the gold placers. The quantity saved is small and is all shipped to Germany.

Further information will be found in THE MINERAL INDUSTRY, Vol. II., in the article on the "Rare Elements," with relation to the use of this mineral.

NICKEL.

THE occurrence and distribution of nickel ores in the United States and Canada were very fully treated in THE MINERAL INDUSTRY, Vol. I., and in Vol. II. an account was given of the working of nickel in different countries throughout the world. Some account of recent improvements in the treatment of nickel ores will be found in the following pages.

The production of nickel ores in the United States in 1894 was practically nothing. In 1893 it showed a heavy decrease on account of the exhaustion of the Lancaster Gap mine in Pennsylvania, which was the chief source of supply in this country. Nothing was done at the Oregon mines during 1894, owing to legal complications in relation to the property, and no ore was produced from the mines in Nevada, although it is stated that preparations were made to commence work in 1894. The demand for nickel was met, however, by the output of the mines of the Sudbury region in Canada, where there appears to be a large supply.

The foreign producers of nickel have been the mines of Norway and Sweden in Europe, and those of New Caledonia, the latter being owned and worked by two French companies, of which the Société du Nickel is the more important. The Swedish mine seems to be practically exhausted; at least they have not been worked to any extent for several years. The Norwegian production continues with but little change. In New Caledonia, however, the report of the Société du Nickel is somewhat reticent as to the state of affairs. It is understood that little has been done at the mines since the great storm in the spring of 1894 which destroyed a number of the company's buildings and other works, and that the company has limited itself, during most of the year, to working up the accumulated stock of ores in France and Scotland. The company has felt severely the sharp competition of the Canadian metal, which could be put upon the market at lower prices than its own product.

The most important use of nickel so far continues to be as an alloy in the manufacture of steel. The tests made of nickel-steel for armor-plates and other purposes during the past year have confirmed the evidence of previous trials as to the quality of the alloy. In other directions its use has not materially extended, although the demand for it continues to increase slightly. The market cannot be largely extended, however, unless new applications are found for the metal.

The accompanying table shows the world's production of nickel for the six years ending with 1894:

THE WORLD'S PRODUCTION OF NICKEL.

(In kilograms.)

Year.	New Caledonia.	Canada.	United States.	Norway.	Sweden.	Total.
1889.....	1,381,482	309,701	98,731	88,500	.....	1,878,414
1890.....	1,633,214	651,239	90,870	70,500	8,050	2,453,873
1891.....	2,449,306	2,098,598	54,815	91,000	12,000	4,705,719
1892.....	1,244,000	1,888,790	43,614	97,000	.....	3,273,404
1893.....	2,045,000	1,811,205	11,745	90,000	.....	3,957,950
1894.....	.....	2,225,996	.....	90,000	.....	.....

While, as noted above, nickel-steel has proved itself probably the best material for armor plate yet tested, the experiments made with this steel in the manufacture of heavy guns have not yet been concluded, so that no decision has been reached as to its adaptability for the purpose. Some experiments have also been begun with nickel-steel guns in France, but there, as in the United States, no conclusion has been reached.

With regard to other uses it may be noted that nickel is employed to a considerable extent in Europe for the manufacture of small articles which are in this country usually nickel-plated only, if the metal is used at all. With the decreasing price, it is evident that there are many manufactures of this kind in which the solid metal might be almost as cheap as the plating on less expensive alloys. In France a copper-nickel alloy is used for some purposes and is said to possess many excellent qualities. Probably other uses might be suggested where the well-known properties of this metal would make it serviceable.

The chief producers in this country are the American Nickel Works at Camden, N. J., the Canadian Copper Company at Brooklyn, near Cleveland, Ohio, and the Orford Copper Company at Constable Hook, N. J. The chief production this year, as stated before, has been by the Orford Company from Canadian ores. From 10% to 15% of the production was in metal, the remainder in oxide, and other salts. In 1893 the total production in the United States, reduced to fine nickel, was 2,912,561 lbs., valued at $799,729, and in 1894 was 4,223,115, valued at $818,869. The greater part of this product was as sulphide and oxide. In 1894 all came from Canadian ores.

The Orford Copper Company was employed some time ago by the United States Navy Department to separate copper from nickel in a large quantity of Canadian matte purchased by the department, and to deliver nickel in the form of an oxide for use in alloying steel. In order to do this the company employed a new process, which may fairly be called the Orford process, and this has been from time to time improved until there is now produced from the Canadian mattes by a fire process metallic nickel which is from 99% to 99.3% pure. The company has been also experimenting with electrolytic processes and has succeeded in obtaining nickel for use in the manufacture of German silver of so great purity that it is now in demand in Europe as well as in this country.

The same company has been experimenting in the use of the metal for various purposes and is turning out nickel rods and has made nickel sheets 20 in. wide.

The Treatment of Pyritous Ores Containing Copper and Nickel.

By Titus Ulke.*

At the Canadian Copper Company's Works, Sudbury ore containing on an average 3% nickel and a little over 3% copper is heap roasted. The coarse ore is piled to a height of 5 to 15 ft. on a 9-in. bed of cordwood; it is then covered with a layer of raggings, and finally topped and banked at the sides with 6 or 8 in. of fines. The piles hold from 600 to 3000 or more tons of ore. Each roast heap burns from 6 to 20 weeks, during which operation the sulphur is lowered to about 7%, the iron is in large part oxidized to ferrous oxide, and the diorite is thoroughly disintegrated by the swelling and oxidation of the ore.

After the ore is thoroughly roasted it is taken to the smelters. These have been so often described that it will suffice to say that the furnaces are of the Herreshoff pattern, of boiler iron, water jacketed, about 9 ft. in height to charging door, of oval section 6 ft. 6 in. by 3 ft. 3 in., with 2-in. water space, and provided with an exterior, brick-lined, water-cooled fore-hearth or well. The capacity of each furnace is about 125 tons of ore or 15 tons of matte in 24 hours, two furnaces being always in operation. The matte is tapped into conical cast-iron matte-pots, in which it is allowed to cool. The slag runs continuously over a slag-lip at the top of the well, and is allowed to flow continuously from the well through an opening in the floor, where a powerful jet of water granulates it and carries it to the dump.

The process of smelting is very economical, the ore furnishing in itself the exact ingredients necessary for fluxing. About 15% of Connellsville coke is used to reduce the ore to matte, or, in other words, one pound of coke makes nine-tenths of a pound of cupola matte. The average grade of matte will analyze as follows: Copper, 20% to 25%; nickel, 18% to 23%; iron, 25% to 35%; sulphur, 20% to 30%. From picked ore cupola matte is sometimes made as high as 52% nickel; the grade is varied to suit the consumer, some desiring high copper and low nickel, and some low copper and high nickel. Any desired proportion of copper and nickel can be made from selected ores.

It is interesting to note that as the mines deepen the ore changes in character from a distinctively copper ore at the surface to a distinctively nickel ore on the lowel levels. Copper Cliff mine, for example, produced on the first level a chalcopyrite, in which the nickel was found by accident, after shipments had been made of the ore as a copper ore alone. On the fourth and fifth levels the ore was about 4% copper and 4.5% nickel, while on the seventh level many stopes show an average of 0.5% copper to 8% and 10% nickel. As these levels are opened the cupola matte will be raised thereby to 25% or 30% nickel.

The next step in the treatment is the refining of cupola matte. At the Canadian Copper Company's refinery at Sudbury the matte, after remelting in cupolas, is run into Bessemer converters, similar to those used in the refining of copper. There are three converters in the refinery, one being always in use,

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* In compiling this article the author has freely used the articles by D. H. Browne, D. Levat, R. M. Thompson, the *Engineering and Mining Journal*, The Mineral Industry, Report of the Metallurgist of the World's Columbian Exposition, and *Annales des Mines*, and especially begs to thank Messrs. D. H. Browne and McIntosh, of the Canadian Copper Company, for their critical revision of the manuscript.

while a second is being relined and a third is in readiness for a charge. The capacity of the Bessemer plant is about 25 tons of cupola matte supplied, or 15 tons Bessemer matte produced in 24 hours. In the converters the iron is almost entirely removed, the sulphur lowered to from 5% to 15%, and the copper and nickel raised to about 45% and 40% respectively. As there are none of the usual flame reactions to guide the operation, the point at which to stop the blowing, after the iron has been removed and before the nickel has commenced to slag in undue amounts, is one in which the skill of the furnace manager is best shown. As the converter slags rarely show over 2% copper and 3.5% of nickel, and as the ratio of copper to nickel in the supply is about 23 to 20 and in the product about 43 to 39, sufficient proof is given of the skill and judgment needed and practiced in the Bessemer concentration of such an easily oxidizable metal as nickel. All converter slags are returned to cupolas for remelting.

For convenience in handling, the converter matte is cast in slabs of 3 ft. square and about 3 in. thick, weighing about 1500 lbs. each. These slabs are lifted on the buggies by hydraulic cranes which serve for handling the converters. A fair average analysis of Bessemer matte is: Copper, 43.36%; nickel, 39.96%; iron, 0.3%; sulphur, 13.76%; silver, 7 oz. per ton; gold, 0.1 to 0.2 oz. per ton; platinum, 0.5 oz. per ton.

After Bessemerizing the matte, the process branches into two distinct parts. For the manufacture of copper-nickel alloys for use in German silver, the Bessemer matte, after roasting to remove all the sulphur, can be reduced direct to alloy, either by charcoal or by reducing gases. A refined copper-nickel alloy containing 50% copper and 49% nickel, with very small amounts of iron, silicon and carbon, is produced direct from Bessemer matte. The economy to German silver manufacturers of purchasing a ready-made alloy, which melts at a low heat and requires simple addition of zinc, instead of buying the nickel and copper separately, is patent to any one. This alloy, "50–50," as it is called, is almost indistinguishable from pure nickel. As its cost is much less than nickel and its melting point much lower, and as it can be cast solid in any form desired, and furnishes a casting which works easily in the lathe or planer, yielding a silvery white surface unchanged by air or moisture, this alloy is destined to have a large use in all hardware specialties where brass or nickel-plated iron is at present used. For the new bullet casings now used in various British and Continental rifles, a special alloy of 80% copper and 20% nickel is made.

The separation of nickel from copper and the methods of producing nickel oxide from Bessemerized matte, have been kept more or less a trade secret until recently.

In the Orford nickel process the metals in the matte are reduced by a preliminary treatment, either as above by the Bessemer process or by ordinary calcining and melting in a blast furnace, to a point where the metals are present substantially as subsulphides. This matte is then melted with an alkaline sulphide (in practice with salt-cake, *i. e.*, sulphate of soda, which in the blast furnace is reduced to sulphide of soda), and a reaction follows in which the copper and iron take the sulphur from the soda. By adding the proper proportion of salt-cake the bulk of the iron and copper are converted into sulphides, and, mixing with the soda, make a very fluid mass from which the subsulphide of

nickel separates by gravity, and on cooling leaves in the tops the bulk of the copper and iron and the soda, and in the bottoms the bulk of the nickel. On exposure to the weather the soda in the tops is converted into caustic soda; these tops are now mixed with matte and remelted, whereby the caustic soda is converted into sulphide of soda at the expense of the nickel, leaving the latter in a semi-metallic state, and again a top and bottom is formed, with copper and iron in the top and nickel in the bottom. By properly balancing these various treatments a pure sulphide of nickel is at last obtained, which by calcining is converted into an oxide.

Heretofore the usual process employed for the production of nickel from its oxide has been the reduction of this oxide, either loose or pressed into cubes, with charcoal in crucibles. This yields a product, which in the case of cube nickel is not strictly a homogeneous metal, but a loose sponge of metallic particles which retain all the impurities contained in the oxide, plus from 0.5% to 2% of carbon. The metal produced by the Canadian Copper Company in their refinery near Cleveland, Ohio, is, however, a solid metal, having been melted direct from the oxide and the carbon and silicon entirely removed. By direct melting alone can a metal free from carbon be produced. A casting of 4500 lbs. of nickel exhibited at the World's Columbian Exposition and made at the Cleveland Works, had the following composition: Ni, 98.78%; Fe, 0.301%; S, 0.068%; Cu, 0.76%; Si, 0.19%; C, none; Sn, none. It is usual in nickel casting to add a small quantity of magnesium or aluminum to make a solid surface; but in this case it was not desirable to spoil an ingot already sufficiently pure by the introduction of any foreign element whatsoever, so the casting was left as it came from the mold.

The following diagrammatic schemes illustrate the various processes employed for extracting nickel and separating it from copper:

THE ALKALINE SULPHIDE PROCESS FOR EXTRACTING NICKEL FROM CANADIAN MATTE.

STAGE I—CONCENTRATION SMELTING.

Material.	Reactions.	Products.
1. Matte. 2. Sulphate of soda. 3. Coke.	1. The Na_2SO_4 is reduced to sulphide. 2. Part of the iron and copper unite with the sodium sulphide.	1. "Tops," consisting of highly cupriferous and ferruginous matte, which goes to the next stage. 2. "Bottoms," highly nickeliferous matte, which goes to the third stage.

STAGE II—"TOPS" SMELTING.

Materials.	Reactions.	Produce.
1. Weathered "tops" from the first and third stages. 2. Matte. 3. Coke.	1. The soda in the tops takes up some S from the Ni in matte and forms a sulphide which unites with part of the iron and copper.	1. "Tops" as in first stage. 2. "Bottoms" as in first stage.

STAGE III—"BOTTOMS" SMELTING.

Materials.	Reactions.	Products.
1. "Bottoms" from first and second stages. 2. Sulphate of soda. 3. Coke.	1. The sulphate of soda becomes reduced to sulpide. 2. Most of the iron and copper unite with the sodium sulphide.	1. "Tops," which go to the second stage. 2. Highly nickeliferous sulphide, which goes to the fourth stage.

STAGE IV—REMOVAL OF IRON.

Materials.	Reactions.	Products.
1. Sulphide from the third stage. 2. Sand. 3. Fuel.	1. Most of the iron and part of the nickel are oxidized by roasting. 2. The silica combines with the oxides. 3. The Nickelretains its sulphur.	1. A ferruginous and slightly nickeliferous slag, which goes to waste. 2. Nickel sulphide, which goes to the fifth stage.

STAGE V—REMOVAL OF SULPHUR.

(Finishing Roast.)

Materials.	Reactions.	Products.
1. Nickel sulphide from the fourth stage. 2. Nitrate of soda in small quantity. 3. Fuel.	The sulphur and nickel are both oxidized. A little salt may be added to convert lime adhering to the bottoms as slag or sulphide into $CaCl_2$, which is afterward removed by washing.	1. Gases which escape. 2. Nickel oxide, which is sold to nickel steel makers, or is reduced direct to refined metal.

The process of making the nickel oxide into bricks with lime, charcoal, etc., was tried by the Canadian Copper Company in 1892 and proved a complete failure. Garnier ran NiO bricks through his cupola and made a pig Nickel—which he tried to refine on a silica bottom—but he could neither make pig nickel continuously nor refine it after he had it made.—DAVID H. BROWNE.

The alkaline sulphide process was first suggested by C. Schafhautl in 1839, followed by W. Jefferies in 1840, T. Bell in 1842 (with a discrimination between "tops" and "bottoms"), and W. Gossage in 1845 and 1850. It has recently been perfected by the officials of the Orford Copper Company, at Constables Hook, N. J., while preparing a supply of nickel oxide for use by the United States Government in the manufacture of nickel-steel armor plates. In this connection it may be mentioned that the use of nickel for improving cast iron was first suggested by M. Poole in 1845, and that its addition to steel was first proposed by T. H. Kelk in 1857.

Nickel prepared in the dry way from oxide obtained by the "Alkaline Sulphide" process as applied to Canadian matte, was formerly found to contain appreciable quantities of copper, iron, cobalt, arsenic, and other impurities, but is now being produced of great purity.

THE AMERICAN PROCESS FOR EXTRACTING NICKEL FROM CANADIAN PYRRHOTITE.

STAGE I—HEAP ROASTING.

Materials.	Reactions.	Products.
1. The ore in small fragments built up into heaps. 2. Cordwood.	1. Much of the S is burnt off. 2. Much of the iron is oxidized to ferrous and ferric oxide.	1. Gases which escape. 2. Partly desulphurized ore.

STAGE II—SMELTING FOR MATTE.

Materials.	Reactions.	Products.
1. The roasted ore from the first stage. 2. Nickeliferous slag from the second and third stages.	1. The gangue of the ore unites with the iron oxide to form a slag. 2. The metals of the ore unite with the S to form a matte.	1. A slag which goes to waste when it is not nickeliferous enough for resmelting. 2. Nickel, iron, copper matte, which goes to the next stage.

STAGE III—BESSEMERIZING.

Materials.	Reactions.	Products.
1. Matte from the second stage. 2. Silica. 3. A blast of air forced through the molten matte.	1. Some of the S and almost all of the iron are oxidized. 2. The silica unites with the iron oxide.	1. A slag which goes to waste when it is not nickeliferous enough for resmelting. 2. A matte very low in iron and rich in nickel and copper.

The Bessemerized nickel-copper matte is now treated in one of the two following ways, according to whether nickel-copper alloys, or nickel oxide and metallic nickel are desired:

1. *Production of Nickel-Copper Alloys.*—In the manufacture of alloys, the matte is roasted to remove the sulphur and directly reduced by charcoal or reducing gases.

2. *Production of Nickel Oxide and Metallic Nickel.*—To manufacture nickel oxide, the copper must first be removed from the matte. This is satisfactorily accomplished in American practice by the Orford or Alkaline Sulphide Process, described above. If metallic nickel is desired, the nickel oxide is reduced by direct melting and reduction. S. H. Emmens proposed to remove the copper from the Bessemer matte by chloridizing the copper and dissolving it in water, leaving nickel oxide in the residue. Trials at Youngwood demonstrated that matte with 20% copper cannot be chloridized so that all of the copper can be extracted from the nickel. A thorough extraction is only possible, according to D. H. Browne, with mattes containing a very low percentage of copper.

The refining of the molten matte by a blast of air was first suggested by Gibb and Gelstharp (British "Provisional Protection," No. 874 of 1870), and was subsequently made practical by Pierre Manhès of Lyons, France; but the process being generally similar to that of Bessemer's prior invention (in 1856) for the conversion of cast iron into steel, it is known by his name. It should, however, be added that Gossage in 1856 proposed to treat "sulphurous ores" by "currents of atmospheric air which are forced up and thro ugh the melted mass." Over 90% of the Bessemer matte production is worked up in to nickel oxide, for making nickel steel, and over 7% of it is converted into pure metallic nickel.

No copper-nickel alloy is now produced in the United States.

THE GOSSAN PROCESS* FOR EXTRACTING NICKEL FROM CANADIAN PYRRHOTITE.

STAGE I—LOW ROASTING.

Materials.	Reactions.	Products
1. The ore. 2. Fuel.	Part of the S burns off and part is converted into H_2SO_4 which combines with the metals present.	1. Gases which escape. 2. A residue, consisting of gangue, iron oxide and metallic sulphates, which goes to the next stage.

STAGE II—WEATHERING.

Materials.	Reactions.	Products.
1. Residue from first stage. 2. Air and moisture.	The ferrous sulphate becomes oxidized into ferric sulphate, which attacks the Ni, Co and Cu.	A mixture, consisting of gangue, iron oxide and metallic sulphates, which goes to the next stage.

* The Gossan process was tried by the Canadian Copper Company, and abandoned. Under the very best laboratory conditions, with a very fine roasted and weathered ore, only two-thirds of the copper and one-third of the nickel was extracted by the ferric sulphate formed.

STAGE III—LIXIVIATION.

Materials.	Reactions.	Products.
1. The mixture from second stage. 2. Water. 3. A jet of steam.	The attack of the ferric sulphate upon the cobalt, nickel and copper is completed. It must not be understood from this, however, that $Fe_2(SO_4)_3$, $CuSO_4$, $NiSO_4$+CuS,CuO form an iron-free solution.	1. Gangue and ferric oxide and hydrate, which goes to waste. 2. Sulphate of Ni (Fe), Co and Cu, which are crystallized out from the solution and go into the market as a material to be refined by the wet process.

THE ORDINARY WET PROCESS, FOR EXTRACTING NICKEL AND COBALT FROM CALCINED ORES, SPEISS AND MATTE.

STAGE I—SOLUTION.

Materials.	Reactions.	Products.
1. The powdered calcined ore, speiss, or matte. 2. HCl. 3. A jet of steam.	The acid dissolves out the soluble metals from the gangue and much ferric oxide.	1. Gangue and ferric oxide, which go to waste. 2. A mixed chloride solution, which goes to the next stage.

STAGE II—REMOVAL OF IRON AND ARSENIC.

Materials.	Reactions.	Products.
1. Solution from the first stage. 2. Chloride of lime. 3. Milk of lime. 4. A jet of steam.	Any acid and ferrous iron present are peroxidized and precipitated.	1. Ferric hydrate and iron arsenate, which go to waste. 2. A mixed chloride solution, which goes to the next stage.

STAGE III—REMOVAL OF COPPER.

Materials.	Reactions.	Products.
1. The solution from the second stage. 2. HCl. 3. H_2S. 4. A jet of steam.	The copper is precipitated in the form of a sulphide.	1. Copper sulphide available for the production of Cu. 2. A solution of Ni and Co chlorides which go to the next stage.

STAGE IV—REMOVAL OF COBALT.

Materials.	Reactions.	Products.
1. The solution from the third stage. 2. Chloride of lime. 3. Milk of lime. 4. A jet of steam.	1. The excess of H_2S is boiled off. 2. Excess of acid is neutralized. 3. The cobalt is peroxidized and precipitated.	1. Cobalt oxide which goes into the market. 2. A solution of nickel chloride.

STAGE V—PRODUCTION OF METALLIC NICKEL.*

Materials.	Reactions.	Products.
1. The solution from the fourth stage. 2. Milk of lime. 3. Charcoal, flour, or other carbonaceous substances. 4. Fuel.	1. Hydrate is precipitated. 2. The dried hydrate is made into a paste with flour and baked. 3. The baked mass (broken into fragments and strongly heated) parts with its C and O and becomes metallic.	1. Gases which escape. 2. Metallic "grain nickel," which goes into the market.

* The nickel thus obtained is commercially pure.

THE EUROPEAN PROCESS FOR EXTRACTING NICKEL FROM THE SILICATED ORE IMPORTED FROM NEW CALEDONIA.

(Low water jackets are exclusively used in this process.)

STAGE I—SMELTING FOR MATTE.

Materials.	Reactions.	Products.
1. The ore. 2. Gypsum. 3. Ground coal. 4. Fuel. } Ground together and pressed into bricks.	1. The silica unites with the Mg and part of the Fe of the ore and Ca of the gypsum to form a slag. 2. The Ni and part of the Fe of the ore unite with the S of the gypsum to form a matte.	1. A slightly nickeliferous slag, which goes to waste. 2. A highly nickeliferous matte, which goes to the next stage.

STAGE II—REMOVAL OF IRON.

Materials.	Reactions.	Products.
1. The roasted matte from the first and fourth stages. 2. Sand. 3. Fuel.	1. Most of the Fe and part of the Ni are oxidized by roasting. 2. The silica combines with the Fe and NiO to form a slag, while most of the Ni retains its S.	1. A slag which goes to the next stage. 2. Nickel sulphide, which goes to the fifth stage.

STAGE III—RESMELTING FOR MATTE.

Materials.	Reactions.	Products.
1. The slag from the second stage. 2. Sand. 3. Gypsum. 4. Fuel. } Ground together and pressed into bricks.	1. The silica unites with the lime and part of the Fe to form a slag. 2. The Ni and part of the Fe unite with the S to form a matte.	1. A slightly nickeliferous slag, which goes to waste. 2. A nickeliferous matte, which goes to the next stage.

STAGE IV—REFINING THE SLAG MATTE.

Materials.	Reactions.	Products.
1. The matte from the third stage. 2. Sand. 3. Gypsum. 4. Fuel.	1. The silica unites with the lime and part of the Fe to form a slag. 2. The Ni and part of Fe retain their S.	1. A slightly nickeliferous slag, which goes to waste. 2. A highly nickeliferous matte, which goes to the second stage.

STAGE V—REMOVAL OF SULPHUR.

Materials.	Reactions.	Products.
1. The nickel sulphide from the second stage. 2. Nitrate of soda in small quantity. 3. Fuel.	1. The Ni and S are both oxidized.	1. Gases which escape. 2. Ni oxide, which goes to the next stage.

STAGE VI—PRODUCTION OF METALLIC NICKEL.

Materials.	Reactions.	Products.
1. The nickel oxide from the fifth stage. 2. Charcoal, flour or other carbonaceous substances.	1. The oxide is made into a paste with flour and baked. 2. The baked mass broken into fragments or molded into cubes, disks, etc., and is strongly heated; parts with the C and O and become metallic.	1. Gases which escape. 2. Metallic "grain," "cube," or "disk "nickel, which goes into the market.

If the original ore contains arsenic, copper, cobalt or manganese, those elements will also be found in the final metallic product, as the above depicted process is incapable of effectually removing them.

Roberts-Austin states, in his report on the British Section of the Chicago Exposition, that the metallurgy of nickel, as carried on in the United Kingdom,

has undergone but little change, except that the use of magnesium and similar deoxidizing materials has enabled the metal to be produced in a readily malleable form. Great interest has been aroused by Mond's discovery that carbonic oxide forms a valuable compound both with nickel and with iron, and hope is held of the successful application of this discovery at the works which are now in operation at Birmingham.

In Europe, the ordinary low-grade nickel matte is refined either in reverberatory furnaces (English method) or by Bessemerizing.

The reverberatory refining, according to D. Levat, requires two operations, each of which includes two phases, viz., roasting, and fusion with quartzose sand to scorify the iron. Each furnace treats 2 tons in 24 hours and consumes 2 tons of coal. Samples are taken in the course of the operation, which lasts about 8 hours, in order to arrest the work as soon as the iron has disappeared, so as to prevent the passage of the nickel into the slag. The latter is never thrown away, for it contains 2% to 2.5% nickel, and also makes an excellent flux. The first operation in the reverberatory gives matte with 2.5% to 3% iron, the second 0.5% to 0.75% at most. The refined matte should contain at least 16% of sulphur in order to be easily pulverized for subsequent operations. The matte freed from iron has the following composition: Ni (Co), 75%; S, 24%; Fe, 0.5%; impurities, 0.5%.

The total impurities should not add to over 1%, for the subsequent operations only remove sulphur. The matte is crushed to 65 mesh, and is roasted in a large roasting furnace (33 ft. long by 8 ft. wide, with four doors on one side) in which the charge is rabbled along toward the fire-bridge. The charge is about 1400 lbs. and the operation lasts 8 hours, or less if copper is present. About 1½ tons are treated per 24 hours, using a ton of coal. The temperature is kept at a dark-red heat to prevent fusion. The operation lasts 6 hours and produces an oxide with a small proportion (about 1%) of sulphur and sulphates. This material is subjected to another roasting after crushing to 120 mesh, and the temperature is raised to a bright red. The resulting oxide (or oxides, for copper oxide is not eliminated), which should not contain over 0.004% sulphur, is formed into cubes or other desirable shapes with water and flour, and reduced with charcoal in a suitable furnace. The copper must be separated from the nickel by one of the wet methods.

Bessemerizing of course requires much less time than the reverberatory method. At Havre, the melted matte is run into the converter (of a ton capacity) and is blown with a pressure of about 40 centimeters of mercury. The temperature rises and a quartzose mixture is thrown on the surface for scorifying the iron. If the matte does not contain more than 36% of iron the latter can be removed in about one hour and twenty minutes. If there is more than this, the bath should be skimmed at least once after the first twenty-five minutes and a new proportion of the flux added. After the final skimming and when the nickel is found to be oxidizing in its turn, the refined matte containing 0.5% of iron is run off. Nearly all of the arsenic, antimony and silver are carried off by the blast or enter into the slag. This slag contains 14% or 15% of nickel, mostly in the form of prills carried into the pasty mass by the blast. Part of this can be recovered by running the slag into pots and allowing the metal to sink to the bottom. The slag must be returned to the furnace.

It would seem natural to continue the action of the blast in the converter upon the matte freed from iron in order to burn out the sulphur, and so obtain refined nickel, which would then only need to be heated in a reducing atmosphere to reduce the nickel oxide which might be formed, as is done with copper. Numerous attempts have been made for this purpose, but it appears impossible to succeed with nickel in this way. After the iron has been removed, the nickel not only oxidizes with the sulphur but the temperature falls, because the combustion of the sulphur, which is lessened by the affinity of sulphur for nickel, does not compensate for the cooling due to the injection of the air. The bath then tends to solidify, and this effect is the more speedy as the uncombined nickel produced can only remain in the liquid state at a very high temperature—near that of molten iron.

The following is a list of various methods for effecting the separation of the nickel and copper, which have been patented in the last year or two:

T. McFarlane, Oct. 11, 1892, No. 484,033. Roasts the ore or matte with a chloride, dissolves out the chloride formed, precipitates iron by a weak alkali solution, adds a small quantity of sodium sulphide to precipitate copper, and precipitates nickel from the remaining solution by soda.

J. De Coppet, Oct. 25, 1892, No. 484,875, and Nov. 22, 1892, Nos. 486,594–5. After the iron has been slagged off he roasts the refined matte and forms sulphates by using an oxidizing flame. The sulphates are leached out and if they contain enough copper sulphate this solution may form the attacking liquid, if not, copper sulphate must be added. The residue is reduced to metal and is acted on by copper sulphate, which dissolves cobalt at the ordinary temperature. After the cobalt is removed the same solvent at a higher temperature dissolves nickel, in both cases depositing an equivalent quantity of copper.

R. M. Thompson, Jan. 10, 1893, Nos. 489,574–6. Smelts ores or mattes with alkaline sulphides in excess, whereby nickel sulphide is formed and sinks to the bottom of the crucible. The "tops" containing alkaline sulphides are used with crude nickel to form the sulphide. The operation is repeated until the separation is satisfactory. The crude nickel is formed by fusing matte with alkaline carbonates.

C. C. Bartlett, June 13, 1893, No. 499,314. Smelts ore or matte with nitercake, salt-cake, or alkaline nitrates or carbonates, whereby nickel sulphide is formed and sinks to the bottom; repeats the operation until pure nickel sulphide is obtained.

D. de P. Ricketts, Oct. 3, 1893, No. 505,846, and Feb. 6, 1894, No. 514,276. Obtains an acid solution of the copper and nickel as sulphates, adds alkalies or alkaline sulphates, still preserving the acidity of the liquid, in order to precipitate the nickel as a basic sulphate, separates the copper from the acid liquid by electrolysis, and recovers the nickel from the sulphate. The nickel salts are converted into metallic nickel by solution to separate insoluble impurities, evaporation, heating in a retort with condenser for collecting the volatile alkalies, and direct reduction of the oxide of nickel to metal.

C. G. Richardson, April 10, 1894, No. 518,117. Separates nickel from copper by fractional distillation of their chlorides in an atmosphere of hydrochloric acid or other neutral gas.

The Nickel Market in 1894.

The consumption of this metal left very much to be desired, and especially during the first six months of the year the demand for German silver was so very slack that the quantities delivered did not cut any material figure. Nickel plating was somewhat better, but also considerably below the average of the few preceding years, and it was only in the second half, or, more strictly speaking, during the last three months of the year, that the deliveries for both these industries became somewhat better, but even at this writing they are not yet up to what might reasonably have been expected.

Production, on the other hand, kept up at rather an increased rate; moreover, improvements were made in the quality of the product, notably by the Canadian Copper Company.

For alloying steel plates the demand was more or less spasmodic, but on the whole satisfactory, and the probability is that very large quantities will be consumed in the future. The largest foreign producer is known to hold rather large stocks in New Caledonia as well as in its smelting and refining works in Europe, and under the circumstances the new competition of the Canadian Copper Company was felt more than ever before, and it is, therefore, not at all to be wondered at that prices showed a declining tendency, and we have to report a material decrease in the value of nickel.

At the beginning of the year prices ruled from 50c. to 55c. for small quantities and 45c. for larger quantities, and these prices were maintained until May when a large reduction was made, and the quotation then was 40c. to 45c. From this time on larger and larger concessions were made until the end of October, when there were free sellers at 40c. for small quantities and 37c. to 38c. for larger quantities, and these prices were successfully maintained. The probability is that consumption during 1895 will materially increase.

The foreign markets followed nearly the same course as our own during the year. The approval of nickel-steel by several European governments, and the adoption of the alloy by Krupp and other large works promise an increased demand for the metal. The probabilities at present are for a wider market at reduced prices.

PETROLEUM.

UNITED STATES.

THE most notable features in connection with the production of petroleum in the United States in 1894 were : 1. The great decline in production of the older fields and the increase of the newer fields. 2. The decline in stocks held at the wells. 3. The increase of prices compared with the previous year. The average price for the crude was nearly 84c. per barrel in 1894, as against 64c. in 1893. When the close of the year drew near oil began to reach still better figures, and in December stood at 95c. at Pittsburg. On Jan. 9, 1895, a sale of 1000 bbls. at Pittsburg at $1 marked the highest price reached in nearly five years. Since January higher figures have been reached, and $1.01 has been quoted at Pittsburg. Prices of refined oil have advanced in proportion. The rise has increased field operations, and although new developments are closely watched the supply seems to be decreasing.

The petroleum-producing localities in 1894 were : 1. The Appalachian field, embracing western Pennsylvania and New York, West Virginia and eastern Ohio. 2. The Limestone field, embracing the Lima district of western Ohio and Indiana. 3. The Florence field of Colorado. 4. The southern California field. 5. The Kentucky field. 6. The Wyoming field.

The total production in 1894 is estimated at about 47,453,105 bbls. of 42 gals., or about 1,000,000 bbls. less than in 1893. The oil produced in Colorado and California seems to be fully absorbed by the local trade, and large quantities of Peruvian oil are imported into California to meet the demands of the consumers. The oil production of Kentucky and Wyoming has not yet reached the point of commercial importance to the trade.

1. *The Appalachian Field.*—The Oil City *Derrick* reports as follows : Nearly twice as many wells were completed in the various oil districts of Pennsylvania, New York, West Virginia and southeastern Ohio in 1894 as in 1893, and at the close of the year there are 704 drilling wells and rigs under way, as against 428 at the close of the year preceding. The productive wells were 1344 and the dry holes 356 greater in number than in 1893. During 1894 2884 productive wells and 872 dry holes were completed, making a total of 3756, as compared with 1540 productive wells and 416 dry holes, or a total of 1956, in 1893. At the close of the past year there were 87 more rigs and 189 more drilling wells under way than at the close of 1893.

Since Jan. 1, 1876, in all 61,271 wells have been completed in the eastern oil fields, representing an outlay of capital of over $18,000,000. There has been a remarkable revival of oil operations in all sections the past year, and the developments in the older sections of the North and Northeast and Middle districts show a considerable increase over those of the preceding year. An advancing market has stimulated new work to a marked degree, and the effects have been felt throughout the entire region. The preponderance of the developments has been confined to the districts of the southwest for several years past, where all the new territory of any consequence has been discovered. However, nearly 25% of all the wells drilled were destitute of oil in paying quantities. While a certain proportion of these produced a greater or less volume of gas and will be commercially valuable in this respect, the greater number represent an expenditure of capital which will never be returned. Over $1,500,000 will have to be charged up to the "dry-hole" account for 1894.

2. *Limestone Field (Indiana and Western Ohio): Indiana.*—The "Hoosier" oil district has grown continually in importance since 1891. It early acquired a reputation for treacherous territory, but its proportion of dry holes to the entire number drilled is not any greater than in other fields. It is less than Pennsylvania and averages about the same as Ohio. A lively campaign has been carried on the past year and the production has steadily increased. The year 1894 has exceeded all others in the development of the district. The number of wells that were drilled in 1893 was more than doubled in 1894. In 1893, 297 wells were completed and in 1894, 1016.

Ohio.—The year has proved a prosperous one to operators in the "Buckeye" district of northwestern Ohio. The demand for the sulphureted product has been excellent, and higher prices have had a stimulating effect upon operations. More wells were completed than during any previous year. Several new pools have been opened up and the older sections enlarged by the discovery of additional territory. Crude oil at the wells had steadily advanced until the quotations at the close of the year reached 55c. per bbl. for North Lima and 50c. for the South Lima product. The efforts of the producers have kept the yield of fuel oil in advance of consumption, and an increase in the net stocks of the pipeline companies has been recorded during the past year. On the whole, 2470 wells were completed in 1894, of which 392, or about 16%, were destitute of oil in paying quantities. There were 1574 wells completed in 1893, and the dry holes numbered 208.

3. *California.*—To the information contained in THE MINERAL INDUSTRY, Vol. II., we may add the following: The yield of crude oil in California, according to *Stowell's Petroleum Reporter*, is now about 50,000 bbls. per month. It sells in Los Angeles at $1.50 per bbl. and retails at 5c. per gal. Heretofore the largest supply has been derived from the Santa Paula field, some distance inland from Los Angeles, in the mountain district. Recently a well bored in the city of Los Angeles struck a good find of oil at a depth of about 1000 ft., and there are now 10 wells in that place with a production of 600 bbls. per day.

4. *Colorado.*—Mr. J. Wallace has kindly furnished the following information regarding the progress of Colorado's petroleum development: In 1894 about 300 bbls. were added to the daily production from new wells. Four refineries are at

present in operation, as the price of oil is nearly twice that of a year ago, and the consumption is steadily increasing. The present daily output of oil is 2200 bbls., or at the rate of 803,000 bbls. per year. From 800 to 900 bbls. "residual" are yearly used for fuel in Colorado, and largely within near range of the field. A large strike of natural gas was made in January, 1895, at a point three miles south of Florence, and the yield is said to be large enough to heat and light an average town of 10,000 inhabitants. Since October, 1894, the Florence & Cripple Creek Railroad has been in regular operation and has greatly stimulated the petroleum industry by affording cheap transportation.

5. *Wyoming.*—According to Mr. W. C. Knight the most noteworthy incident for the year 1894 was the placing of Wyoming petroleum on the general market. The Pennsylvania Oil Company, which controls the Salt Creek oil basin, which is 50 miles north of Casper, commenced work in February by erecting tanks at Casper and putting on freight trains to transport the oil. The demand for the oil for lubricating purposes grew so rapidly that before the year ended they could not supply the demand. The company immediately contracted for sinking more wells, and at a meeting held in December it was decided to erect a refinery at Casper, and as soon as advisable to put in a pipe line to connect the wells with the refinery. The oil is of superior quality, having a greenish cast by reflected light; has a sp. gr. of .9150 as pumped from the wells and flashes at 221° F. It contains nearly 50% of lubricating oil ranging from .8888 to .9026 sp. gr.; about 3% of coke and less than 0.2% ash. The oil is found in the lower Cretaceous rocks at depths varying from 700 to 1000 ft. The output of oil from the Salt Creek field for the year 1894 was 2300 bbls. (50 gals. each), valued at $23,000.

About 120 miles west of Casper, on the Little Popo Agie River, there are three wells packed, awaiting the construction of a railroad. These wells are found in Triassic rocks and are from 300 to 800 ft. in depth. The oil is black by reflected light, has a sp. gr. of .9210, contains 20% of kerosene and 65% of lubricating oil. It is estimated that these wells are capable of producing about 600 bbls. per day.

The Oil Market in 1894.—The market, especially that for refined oil, during 1894 presented some features differing from those of any preceding year. The foreign demand was very large, but there was a decrease in prices. American oil has had to meet abroad the competition of the Russian product, which is increasing in keenness and extent every year. This competition is specially felt in Eastern Europe, which is the natural market for the Russian product, and in Eastern Asia, where until a comparatively short time ago the American oil entirely controlled the market. To meet this competition the American exporters have had to make concessions with regard to prices, so that the increase in exports recorded last year was accompanied by an actual decrease in the value reported.

The total exports of crude oil, refined oil and all products from the United States, as reported by the Bureau of Statistics of the Treasury Department, for the year 1894, were 894,862,159 gals., valued at $40,463,088. For the year 1893 the total exports were 871,757,017 gals., valued at $41,117,814. That is, while the exports showed an increase in quantity of 23,105,042 gals., their declared value showed a total decrease of $654,926.

For domestic sales the prices of refined and illuminating oils ruled at very nearly constant figures throughout the year, and the market quotation in New York was about 5.15c. with hardly any variation until December. In December there was a little excitement, and following the rise in crude oil noted above the refined product also increased in price, rising to 5.80c.; however, the average price for the year was lower than had ever been recorded before, showing a decrease even from 1893, when the price of illuminating oil was thought to have reached the lowest point possible.

The course of prices of illuminating oil for 12 years past has been as follows, the standard being the price per gallon of 70° Abel test refined oil in New York:

AVERAGE PRICE PER GALLON OF ILLUMINATING OIL IN NEW YORK.

Year.	Cts. per Gal.	Year.	Cts. per Gal.	Year.	Cts. per Gal.	Year.	Cts. per Gal.	Year.	Cts. per Gal.	Year.	Cts. per Gal.
1883	8.14	1885	7.86	1887	6.75	1889	7.19	1891	6.85	1893	5.25
1884	8.28	1886	7.07	1888	7.50	1890	7.33	1892	6.06	1894	5.17

Some interesting statements with regard to the Russian oil fields will be found in the article on "Russia" in the present volume. The statistics of the trade from 1890 to 1894, inclusive, are given in the following tables. Those for the years prior to 1890 will be found in THE MINERAL INDUSTRY, Vol. II.

PRODUCT OF CRUDE PETROLEUM IN THE UNITED STATES SINCE 1889.

(Barrels of 42 gallons.)

Year.	Pennsylvania and New York.	West Virginia.	Ohio.	Indiana.	Colorado.	California.	Kentucky and Tennessee.	Wyoming and Other States. (a)	Total. United States.
1890	28,458,208	492,578	16,124,656	63,496	368,842	307,360	6,000	1,532	45,822,672
1891	33,009,236	2,406,218	17,740,301	136,634	665,482	323,600	9,000	1,504	54,291,980
1892	28,422,377	3,810,086	16,362,921	698,068	824,000	385,049	6,500	135	50,509,136
1893	b30,541,740		16,134,485	2,232,303	730,000	600,000	9,000	1,700	50,349,228
1894	b30,622,336		13,891,795	2,606,505	803,000	600,000	1,000	2,700	48,527,336

(a) Illinois, Kansas, Texas, Missouri, Indian Territory, and Wyoming. (b) The crude from West Virginia and southwestern Pennsylvania being run into mutual pipe lines, its production cannot be given separately for each State. (c) Buckeye pipe line runs + Macksbury production. (d) Wyoming.

EXPORTS OF MINERAL OILS FROM THE UNITED STATES SINCE 1889, IN GALLONS.

(1=1000 in quantities and values.)

Year.	Crude Petroleum.		Naphthas.		Illuminating.		Lubricating and Paraffine.		Residuum.		Total.	
1890	96,573	$6,535	12,462	$1,051	550,873	$39,826	39,461	$7,687	1,831	$92	601,200	$55,099
1891	96,723	5,366	11,424	868	531,445	34,880	41,247	7,979	1,003	61	681,842	50,193
1892	104,013	4,660	16,351	1,033	586,406	31,488	33,805	5,071	329	31	740,905	42,283
1893	114,609	3,926	16,249	933	705,675	31,283	34,763	4,888	461	28	871,757	41,118
1894	114,269	4,617	14,832	904	726,727	29,799	38,975	5,137	60	6	894,862	40,463

MONTHLY AND YEARLY AVERAGE PRICE OF PIPE LINE CERTIFICATES PER BARREL OF CRUDE PETROLEUM AT THE WELLS SINCE 1889.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Average.
1890	$1.05¾	1.05⅛	.90	.82⅝	.88⅞	.89¼	.89⅛	.89¼	.81⅞	.80⅛	.72⅜	.67¼	.86¾
1891	.74¼	.78⅜	.74¼	.71½	.69¾	.68⅛	.66½	.64	.58½	.60¼	.58¾	.59⅛	.67
1892	.62⅜	.60¼	.57⅛	.57⅜	.57⅜	.54⅛	.52½	.55	.54⅜	.51⅜	.52	.53¼	.55⅝
1893	.53½	.57⅜	.65¼	.68¾	.58⅞	.60¼	.57⅜	.58⅞	.64⅝	.70¾	.73⅞	.78¼	.64
1894	.79¾	.80⅝	.82	.84¼	.86	.89⅜	.83⅞	.81	.83	.83	.83	.91½	.83⅞

The World's Production of Petroleum.

The following interesting table, which has been compiled from official sources, shows the production of petroleum in the world from 1860 to 1894 in the different countries and brought up to the latest possible date. The production of Russia, which began very early in the century, and really before that of the United States, reached at that time only a very small figure, and previous to 1860 never exceeded 3500 metric tons of crude oil in any year, generally falling considerably below that. The first refinery was established in 1860 at Sourakhan, and in 1864 the first refining works at Baku were started; from the latter date really commenced the commercial production of petroleum in Russia, which has now reached such an important figure.

THE WORLD'S PRODUCTION OF PETROLEUM. (*a*) (IN METRIC TONS.)

Year.	Austria.	Hungary.	Canada.	Germany	India.	Italy.	Japan.	Russia.	United States.
1860	.....	.....	.....	.....	.....	5	.....	1,440	69,950
1861	.....	.....	.....	.....	.....	4	.....	1,860	295,690
1862	.....	.....	.....	.....	.....	4	.....	1,890	427,620
1863	.....	.....	.....	.....	.....	8	.....	1,950	365,320
1864	.....	.....	.....	.....	.....	10	.....	4,590	306,040
1865	.....	.....	.....	.....	.....	315	.....	4,880	349,400
1866	.....	.....	.....	.....	.....	138	.....	5,200	503,300
1867	.....	.....	.....	.....	.....	110	.....	5,730	468,250
1868	.....	.....	.....	.....	.....	51	.....	5,740	360,450
1869	.....	.....	.....	.....	.....	20	.....	8,030	589,680
1870	.....	.....	.....	.....	.....	12	.....	9,780	736,000
1871	.....	.....	.....	.....	.....	38	.....	10,040	728,180
1872	.....	.....	.....	4,094	.....	46	.....	20,040	880,400
1873	12,000	.....	.....	1,700	.....	65	.....	28,700	1,384,170
1874	14,778	1,781	.....	892	.....	84	.....	34,400	1,528,680
1875	15,555	1,693	.....	781	.....	113	.....	40,180	1,701,465
1876	17,450	1,967	.....	593	.....	402	.....	68,880	1,277,600
1877	18,433	1,966	.....	865	.....	408	.....	71,960	1,867,670
1878	22,066	1,793	.....	845	.....	602	.....	126,280	2,154,000
1879	28,433	1,640	.....	1,895	.....	402	.....	143,500	2,785,970
1880	32,000	1,646	.....	1,309	.....	283	.....	177,940	3,678,202
1881	39,844	1,875	.....	4,108	.....	172	2,333	210,330	3,869,936
1882	46,100	1,743	.....	8,158	.....	183	2,711	269,087	4,268,608
1883	70,766	.....	.....	3,755	.....	225	2,862	248,082	3,289,513
1884	35,000	21	.....	6,490	.....	396	820	333,168	3,392,479
1885	50,000	14	.....	5,815	.....	270	968	559,347	3,060,311
1886	65,000	6	68,062	10,385	.....	219	1,780	619,475	3,931,277
1887	80,000	29	106,889	10,444	.....	208	1,165	755,260	3,961,257
1888	100,000	35	102,625	11,920	.....	174	4,760	853,736	3,867,848
1889	112,000	68	89,530	9,591	12,214	177	6,531	1,048,193	4,925,647
1890	122,500	990	107,020	15,226	6,437	417	6,720	1,146,172	6,418,765
1891	123,006	.....	105,660	15,315	20,455	1,131	7,400	1,249,592	7,978,923
1892	120,000	20	109,080	14,527	29,084	2,548	9,825	1,290,537	7,000,982
1893	122,000	14	111,700	13,974	.....	2,652	13,276	1,396,519	6,978,403
1894	.....	.....	116,000	.....	.....	.....	.....	.....	.....

(*a*) From official reports.

PYRITES.

PREVIOUS to 1894 the production of pyrites in this country was almost entirely from Virginia and Massachusetts. The mines of Louisa County, in the former State, and those of the Davis Pyrites Company, in the latter, were the chief sources of supply. In 1894 South Carolina made a considerable figure as a producer, furnishing 12,000 tons, or about 10.5% of the total.

The following table gives the production and imports of pyrites, showing approximately the consumption in the United States for the five years from 1890 to 1894, inclusive. No pyrites are exported, so that the third column shows the actual amount used very nearly.

IRON PYRITES INDUSTRY IN THE UNITED STATES.
(In tons of 2240 lbs.)

Year.	Production.		Imports.		Consumption.	
1890.....	111,836	$273,745	115,000	$345,000	226,386	$618,745
1891.....	109,319	317,280	130,000	400,000	239,319	717,280
1892.....	106,250	357,000	210,000	630,000	316,250	987,000
1893.....	95,000	285,000	194,000	582,000	289,000	867,000
1894.....	a114,462	366,467	146,023	590,905	260,485	957,372

(a) Of this tonnage there was produced in Virginia 62,522 tons, worth $203,197; Massachusetts 39,940 tons, worth $124,270; South Carolina 12,000 tons, worth $39,000.

It will be seen that the total consumption, which showed in 1893 a decrease of 27,250 tons, or nearly 9%, from that of 1892, experienced in 1894 a still further decrease of 28,515 tons, or nearly 10%, making the total reduction 55,765 tons as compared with 1892. The latter year was that in which the consumption reached its maximum, and the quantity reported last year was still greater than for any year prior to 1892. This table does not include certain copper pyrites u sed to make acid in Arizona, nor zinc sulphide used for the same purpose at La Salle, Ill., nor some pyrites used for acid making in Colorado.

The increasing use of pyrites in the manufacture of sulphuric acid is re ferred to in another article. That manufacture furnishes the chief demand for the mineral, which thus depends upon the prosperity of the chemical industry.

There was but little change in prices during the year. The native ores realized on an average from $3 to $3.25 per ton at the mines, and the price of pyrites delivered at consuming points did not vary far from 10 cents per unit of sulphur.

PRECIOUS STONES.

THE production of precious stones in the United States continues to be quite inconsiderable and no new discoveries of importance can be reported during 1894. From time to time stones are found which are believed to be but are seldom diamonds. Garnets are found in Arizona, New Mexico and New York, and the New Mexican stones are of good quality. Pearls have been found at various times in Wisconsin, Texas, Tennessee and Kentucky, and still continue to be found in small quantities. The imports of precious stones into this country, particularly of diamonds, amount in value to a large sum; the total will be found on another page.

The diamond market of the world continues to be controlled by the De Beers Consolidated Company, which owns all the South African mines from which the chief supply is derived, with the exception of the Jagersfontein, the production of which has so far been inconsiderable. The method of working at the Kimberly mine, which is followed in a general way at the other mines of the company, was described in THE MINERAL INDUSTRY, Vol. II. The Brazilian diamond mines were described in Vol. I.

During the past year some improvements have been made by the De Beers Company in the methods of working and washing the diamond-bearing earth, or "blue ground," as it is locally and technically called. Since the discovery of these mines the work has been carried on under the supposition that crushing would destroy or injure the stones. Believing that if the hard clay could be crushed it would very much facilitate the work, a series of experiments were made which showed that a crushing process was possible. Accordingly, a large crushing plant has been erected at the De Beers mine which was brought into operation at the close of the year. The plant was designed and erected under the supervision of Mr. Gardner T. Williams, the general manager of the company, and is described as follows in the company's last annual report:

The object of erecting this plant is to crush the large accumulation of hard "blue ground" from the De Beers mine, which does not disintegrate by exposure on the floors, and also to crush the cylinder lumps from the old washing machines, which contain about 50% of hard blue which would otherwise for a time be of no value.

The hard blue ground and lumps are taken to the top of the new plant by means of an endless iron rope haulage. After leaving the haulage the

trucks run by gravitation alternately to two hoists, where they will be hoisted and the contents automatically tipped into bins. From these bins the ground runs into large "comet" crushers, which reduce it so that the largest pieces will pass through a 2-in. ring. From these crushers the ground passes through revolving screens having perforations ½ in. and 1¼ in. round, the finely crushed ground being separated from the coarse, and flowing directly to the finishing mill. The 1¼ in. product passes around the small crushers directly to the picking tables. The coarse ground from each large crusher (of which there are four) goes through two small crushers, thence through revolving screens, where the ground is separated into two sizes; that which passes through a ½-in. perforation goes direct to the finishing mill; that which passes through the end of the cylinders is deposited upon revolving tables, where any specially large diamonds may be found, thus preventing the risk of their being crushed.

The ground is scraped off the picking table automatically into two sets of rolls, where it is further reduced, passes into screens, and is graded into three sizes, ½ in., ¾ in. and a coarser size. The latter two pass into the jigs and the fine size goes direct to the finishing mill.

Large diamonds which have become separated from the matrix are retained in the jigs. The blue ground passes out at the end of the jigs to the rolls and is again made finer; and then flows through a launder to an elevator, which takes all the fine ground to the top of the finishing mill. Here it is again screened in four sizes, ½ in., ⅜ in., ¼ in., and ⅛ in., and the various sizes pass through a series of jigs; the coarser sizes, ½ in. and ⅜ in., after being jigged, pass to the rolls, and then to the final set of jigs. The finished product is drawn from the bottom jigs into locked trucks running upon tracks at the lower level, and thence conveyed to the pulsator, where it is sorted. After leaving the last jigs, the water is separated from the fine ground by means of revolving screens, covered with sieving of very fine mesh. The tailings are then taken away in trucks to the tailings heap.

The following table shows the production of the De Beers Company's mines for five years past:

PRODUCTION OF DIAMONDS FROM THE DE BEERS CONSOLIDATED MINES.

Year. (a)	Loads Hoisted.	Loads Washed.	Loads on Floors at Close of Year.	Value Per Carat.	Per Load.		Value of Product.	Dividends.		Capital Stock.
					Carats.	Cost of Working.		Amount.	Per Cent.	
1889–90...	2,192,226	1,325,400	1,576,821	$7.82	1.09	$2.13	£2,330,180	£789,791	20	£3,948,955
1890–91...	1,978,153	2,105,182	1,449,792	7.08	0.96	2.08	2,974,670	888,575	22½	3,948,955
1891–92...	3,338,553	3,239,134	1,624,803	6.12	0.92	1.78	3,931,543	987,239	25	3,948,955
1892–93...	3,090,183	2,108,626	2,606,362	6.97	1.05	1.67	3,239,389	987,329	25	3,948,955
1893–94...	2,999,431	2,577,460	3,028,033	5.86	0.89	1.58	2,820,172	987,329	25	3,948,955

(a) For 1889–90 and 1890–91 the company's year ended March 31; 1891–92 included 15 months; 1892–93 and 1893–94, years ended June 30. The total values, capital stock and dividends paid are in pounds sterling; averages per carat and per load have been reduced to dollars and cents.

QUICKSILVER.

WHILE no new developments in quicksilver mining are to be noted during the year, production and demand showed very little decrease, in spite of the fact that the prices during the earlier part of the year were the lowest on record, though later there was some improvement in this respect. In the United States, indeed, the production increased by a small amount, and the total of 27,999 flasks of 76.5 lbs. each reported for 1892 was increased in 1893 to 30,164, and in 1894 to 30,440 flasks, the increase coming chiefly from the New Almaden, the Redington and the New Idria mines in California, while one mine, the Altoona in Trinity County, was reopened and again became a producer, although its output did not appear upon the market before the close of the year. The following table, for the figures in which we are indebted to the Hon. James Butterworth Randol of San Francisco, gives the production of the various mines for 1894, to which we have added, for purposes of comparison, the figures from the same mines in 1893:

PRODUCTION OF QUICKSILVER IN CALIFORNIA IN 1894. (IN FLASKS OF 76.51 LBS.)

Month.	New Almaden.	Napa Con'd.	Mirabel	Ætna.	Great Western.	Great Eastern.	Sulphur Bank.	Redington.	New Idria.	Lake.	Abbott.	Total.
January ...	800	415	377	375	310	120	75	100	70	.....	100	2,742
February ..	800	370	220	295	400	113	110	100	65	.....	100	2,573
March	650	410	250	245	589	137	31	100	50	.....	100	2,562
April	600	400	385	280	434	81	71	100	60	.....	100	2,511
May	500	455	391	295	425	105	61	100	70	.....	100	2,502
June.....	450	400	392	265	400	101	.....	100	85	.....	100	2,293
July.....	500	400	393	325	455	109	.....	100	75	.....	100	2,457
August	567	350	400	375	386	46	.....	100	80	.....	100	2,404
September.	593	200	424	240	391	73	.....	100	80	.....	100	2,201
October....	525	555	372	360	575	164	.....	100	80	.....	100	2,831
November .	600	540	285	230	476	171	.....	100	155	.....	100	2,657
December .	650	435	340	290	500	148	.....	109	135	.....	100	2,707
Total	7,235	4,930	4,229	3,575	5,341	1,368	348	1,209	1,005	.....	1,200	30,440
Total, 1893.	6,614	6,120	5,211	3,795	3,187	1,445	1,200	1,012	869	578	133	30,164

The year was not a favorable one for the California producers; the close competition of the Rothschilds, who control the European product, and a report that the duty on quicksilver was to be removed so demoralized the market in San Francisco that it opened at $30 per flask, the lowest price ever known in California. This reduction of about 25% from previous quotations had been made just previous to the close of 1893, and at this price it was claimed that it would

be impossible for the California mines—with perhaps one or two exceptions—to continue in operation. The extremely low prices, however, did not continue, and a gradual rise began, which continued until September, when the ruling rate was $37 per flask, and this continued in force until the end of the year, and in fact for some months into 1895. Recently another increase of $1 per flask is reported. The removal of the duty on imports was not made, and the new tariff still leaves a tax imposed upon the metal.

The prices referred to above are those for domestic consumption; for export the market has always ranged from $2.50 to $4 per flask below the local rates, since the quicksilver exported has to compete in Mexico and South America, where it finds its chief sale, with the output of the local mines and also with the European product. During the period of greatest depression lots were sold for export to Mexico as low as $27.50 per flask. The following table shows the range of prices during the year in San Francisco:

RANGE OF QUICKSILVER PRICES IN SAN FRANCISCO IN 1894.

Month.	Highest.	Lowest.	Month.	Highest.	Lowest.	Month.	Highest.	Lowest.
January....	$30.00	$27.50	May	$36.00	$34.75	September..	$37.00	$35.00
February..	32.50	30.00	June.....	36.00	28.00	October.....	37.00	36.00
March	34.00	32.50	July.....	36.00	36.00	November..	37.00	37.00
April.....	35.00	33.25	August	36.00	35.00	December...	37.00	37.00

Highest for the year 1894, $37; 1893, $43.50. Lowest for the year 1894, $27.50; 1893, $30 per flask.

As the price a few years ago ranged from $41 to $42 per flask it will readily be seen that there has been a material reduction in the profits of the mines; to some extent this may have been met by reductions in operating cost, but the probability is that had the low prices continued all but the larger and more economically worked mines would have been obliged to close down. The actual cost of mining and reducing the metal is said to be in some mines as low as $15 per flask, although it has not been possible to obtain exact figures. At the present time the California producers are well organized, and are united closely in a combination which regulates production and also prices as far as possible, although the latter depend almost entirely on the figures made by the Rothschilds abroad.

The total amount of the production marketed in San Francisco was somewhat less in 1894 than in 1893—24,965 flasks, against 26,514. The balance of the production is shipped either eastward or to Mexico by rail direct from the mines, or sold and used in the State. A considerable part of the exports to Mexico, however, are made through San Francisco and shipped from that port by water. While there was a decrease in the demand from the silver mines this was to some extent offset by the increased demand coming from the new gold mines opened and the old ones reopened in California and in the adjoining States. From Mexico little or no change was apparent in the demand, so that the total consumption did not vary greatly.

The Chinese market, which at one time promised to become of considerable importance in the trade, has been practically lost. The shipments to China and Japan were 3800 flasks in 1893 and only 2000 flasks in 1894, and the market has been taken by the output of the European mines, which can be placed in the

Chinese ports at a lower price than the Californian producers are willing to accept.

No changes, with the exception of the opening of the Altoona mine as above noted, can be reported in the State during the year, and there was no notable improvement made in the methods of working the mines or in metallurgy.

The quicksilver production of the world for five years past, including the figures for 1894, as far as attainable, are given in the following table; the figures for the years previous to 1890 will be found in THE MINERAL INDUSTRY, Vols. I. and II.:

QUICKSILVER PRODUCTION OF THE WORLD. (*a*) (IN METRIC TONS.)

Year.	Austria.	Italy.	Russia.	Spain.	Mexico.	United States.	Total.
1890	542	449	292	1,813	.....	796	3,892
1891	570	330	324	1,665	.....	794	3,683
1892	542	325	343	1,682	.....	971	3,863
1893	511	273	367	1,672	.....	1,047	3,870
1894	.....	.....	.....	1,653	268	1,056	.....

(*a*) In Mexico one mine reports for 1893 a production of 3388 flasks, valued at $190,575; for 1894 the output was 2009 flasks, valued at $123,554; these values are in Mexican silver dollars. Reports from other Mexican mines give an approximate output of 5720 flasks for 1894.

The close similarity between the totals for 1892 and 1893 is remarkable, and it is probable moreover that the complete figures for 1894 will show but very slight variation. The New Almaden mines in Spain continued to be worked steadily, and some new deposits were opened. The Idria mines in Austria have not been increasing their production, and the Italian mines are decreasing slightly; on the other hand there has been an increase in the Russian output, and a new deposit of cinnabar is reported to have been opened in the Caucasus, from which much is expected. In Russia also it is understood that the Auerbach works in the government of Ekaterinoslav have been making many improvements in machinery and methods of reducing the ore, so that an increase of output may be expected hereafter.

The range of prices on the London market and other statistics for five years are shown in the following table:

LONDON QUICKSILVER MARKET. (*b*.)

(1 Flask=76.5 lbs.)

Year.	Production.		Imports into London.		Total.	Exports from United Kingdom.	Price of Spanish.	
	Austrian.	Californian.	Italian.	Spanish.			Highest.	Lowest.
	Flasks.	Flasks.	Flasks.	Flasks.	Flasks.	Flasks.	£ s. d.	£ s. d.
1890	14,000	22,926	12,470	50,202	99,598	56,702	10 7 6	8 17 6
1891	15,000	22,904	10,440	47,993	96,337	63,143	9 0 0	7 5 0
1892	15,000	25,554	6,765	47,321	94,640	46,055	7 15 0	6 1 0
1893	15,000	30,164	6,680	44,670	96,514	42,265	6 17 6	6 2 6
1894	15,000	30,440	8,700	42,414	96,554	41,046	6 15 0	5 10 0

(*b*) From the Annual Metal Circular of W. T. Sargant & Sons.

The lowest quotation for 1894—£5 10s. per flask—is the lowest on record, and was in January. From that point on the recovery was gradual up to the end of the year.

Spain.—For the following statement of the work done at the Almaden mines during 1894 we are indebted to the *Revista Minera:* During the year there were excavated at Almaden 6680 cubic meters of ore, and only 561 cubic meters of barren rock had to be taken out. Most of the mineral was obtained in the crosscuts and galleries on the twelfth level, and it was on this level that most of the stoping has been done during the year. The permanent work required the construction of 8309 cubic meters of masonry in the various galleries and chambers. In weight the extraction for the year amounted to 19,428 metric tons of ore and 1828 tons of barren rock.

The development work, which is most interesting if we consider the future of the mine, has consisted of the running of a long crosscut on the twelfth level, starting from the San Teodoro shaft at a depth of 340 meters, the general direction being toward the San Pedro and San Diego shafts, which it is expected will be reached by the end of the present year. The intention is to continue crosscutting northeast of the San Nicholas shaft. It is also intended to open communication between the eleventh and twelfth levels. All this work, together with that of taking out the necessary amount of mineral to keep up the production, will require some time, especially as all the work now planned will be ended in the year 1900, when the well-known contract with the Rothschild house will terminate. In order to hasten the work it is proposed to have recourse to the use of power drills, as proposed some time ago by the mining engineer.

In the furnaces of the Almaden during the year 1894 there were 18,744 tons of ore treated, which produced altogether 44,521 flasks of quicksilver, representing a total weight of 1,535,988 kilograms of the metal, the average yield of the mineral treated having been 8.19%. This shows an improvement over the preceding year, when the yield was only 7.82%. The furnaces were run for seven months of the year, having been shut down through the hot season, from May to September, inclusive. The highest yield reported was 8059 flasks in December, and the lowest 2912 flasks in October.

Mexico.—The Mexican mines were with some exceptions worked to their usual capacity in 1894, although it has been difficult to obtain returns. The demand in that country has not decreased, as the silver mines continued generally active throughout the year, and the domestic consumption is considerably larger than the production, requiring the importation of a considerable quantity. There are two large and important quicksilver mines in Mexico; the first—which is said to be the largest producer—is the Huitzuco mine in the State of Guerrero, which is the property of Don Manuel Romero Rubio, at present Secretary of State of Mexico; the other important mine is the Guadalcazar, owned and operated by an English company, the Compania de Minas de Azogue de Guadalcazar. The Huitzuco mine produced in 1894 an average of 100 flasks a week. In addition to the two mines named above, the Nueva Potosi Company at Guadalcazar produced about 10 flasks a week and is now putting in new furnaces, which will raise the output to 25 flasks weekly.

The total production of the Guadalcazar mines, according to Mr. S. W. Stackpoole, the chief engineer, for the year 1893 was 3388 flasks of quicksilver (75 lbs. per flask). The average grade or quality of all ore treated in the furnaces during that year was 4.05%, and the percentage of the quicksilver extracted from

the ore amounted to 83.56%. The average price for the same period was 75c. (Mexican silver) per lb. For the year 1894 the total production of the mine was 2009 flasks (of 75 lbs. per flask), and the average percentage or richness of all ore treated during this year (1894) was no more than 1.95%. The quicksilver extracted and saved from this ore reached 81.87% of the total metal contents. The average value of the metal for the year was 82c. (Mexican silver) per lb.

It is not believed that the mine is giving out or failing rapidly, although at the present moment it is not looking particularly well. The great requirement is vigorous development, which has always been very much behind, if not entirely neglected. The country rock in the immediate neighborhood is chiefly gypsum and limestone, although less than a mile to the east of this company's property are several silver lodes, where the gangue is porphyry and granite. One of those silver deposits (the San Rafael mine) is now being reopened.

The Guadalcazar Company's furnaces are all of the muffle type; the mercurial fumes or vapors driven off from the ore by the heat pass into a series of cast-iron dust-boxes and condensers, then through a number of brick settling chambers with baffle walls (cement plastered), before they finally make their exit through the chimney, with which the fire-flues are connected. It will be seen from the percentages of quicksilver reported lost (16.44% in 1893 and 18.13% in 1894) that the furnaces are rather wasteful; also that the performance for the year 1894 is not equal to the results obtained during the previous year, owing to the lower grade of the ore.

All the ore extracted from the mines was treated on the spot and in the company's own furnaces. Since the close of the year the price of quicksilver has risen to 89c. (Mexican silver) per lb., and the markets are strong. There is always a good demand for this article in Mexico, as there is a great quantity used in the "Patio" and other amalgamation processes for the extraction of silver from its ores.

The Nueva Potosi Company reports that for the period from June 15 to Dec. 31, 1894, its production was 240 flasks of quicksilver, having an average value of $62.25 (Mexican currency) per flask. According to the information furnished us by Mr. W. H. Randall, engineer in charge, the present company has only taken over and worked the mines recently. They are old mines, which were extensively worked 15 or 20 years ago, when quicksilver brought a high price, but had been abandoned for the last four or five years. This company commenced work at the beginning of 1894, a small 6-ton furnace being completed by the middle of June of the same year. From the middle of June to the end of December 240 flasks were produced, an immediate sale being found for them in San Luis Potosi, the nearest town of any importance. The ore is poor, averaging less than 1%, but occurs in large bodies and is easily mined; labor, wood-fuel, etc., are very cheap. The company has just completed a second furnace with a capacity of 14 tons per day, and is now producing 30 odd flasks of quicksilver per week.

THE RARE ELEMENTS.

THE rare elements were very fully treated in THE MINERAL INDUSTRY, Vol. II., and in that article their properties and uses were fully explained; to this subject there is very little to be added.

Until within the past two or three years the separation of these metals from their combinations has been chiefly based on the use of nitric acid as a solvent, on the variable solubility of the double sulphates, and on the action of ferrocyanide of potassium and oxalic acid. Although other methods are employed these have been the principal ones. The second named method is chiefly used in separating the cerium and yttrium groups. Any one method of fractional crystallization will, as a rule, separate the elements up to a certain point; but, as chemists have remarked, after a time a special method seems to lose its power and another must be adopted. By varying the process and using each in turn, however, the separation can usually be extended to the fullest point desired.

Within the past two years a new element has been introduced by which chemists have accomplished the reduction of some of the rarer metals which had heretofore been regarded as impossible. This is the electric furnace, a device by which we have been able to obtain a higher degree of heat than had ever before been reached. The intense and concentrated heat possible in this device is particularly useful to the experimenting chemist. M. Henri Moissan in France has been a pioneer in the use of the electric furnace, and has reached some exceeedingly interesting conclusions through its use; while others are following on the lines which he has indicated. It is in this direction, obtaining the metals by fusion, that the greatest advance was made during the past year.

As a matter of information for those who are interested we append a table of the prices of the rarer metals. The prices given for 1893 are usually those charged at the works in Germany where they are to be obtained. The prices for 1894 were furnished by Messrs. Eimer & Amend, of New York.

PRICES OF THE RARER METALS.

All prices are per gram, except where otherwise specified.

Metal.	1890.	1893.	1894.	Metal.	1890.	1893.	1894.
Barium, ex amalgam	$2.00	$2.12	$4.00	Manganese, pure (per 10 grams)	$2.25	$2.25	$5.00
Barium, electrol	7.50	7.75	.....	Molybdenum, powder (per 10 grams)	1.25	1.25	1.00
Boron, amorphous	1.50	1.12	.....	Niobium	.....	.....	4.00
Boron, crystalline	2.62	2.75	4.25	Osmium	1.12	1.00	2.00
Calcium, electrol	5.00	5.25	10.00	Palladium, sheet and wire	1.00	1.06	1.50
Cerium, powder	1.00	2.25	4.50	Palladium, powder	.87	1.00	.80
Chromium, metallic	.40	.40	.30	Potassium (per kilo)	.....	.....	22.50
Chromium, crystalline	.75	.75	.....	Rhodium	1.00	1.62	3.25
Cobalt, commercial (per kilo)	8.75	10.00	8 40	Rubidium	6.25	6.25	10.00
Cobalt, pure (per kilo)	32.50	40.00	32.00	Ruthenium	3.25	2.50	1.60
Cobalt, powder (per 100 grams)	4.00	.....	1.28	Selenium, pure crystal	.50	.50	1.00
Columbium, powder	4.00	.....	6.00	Selenium, commercial	.....	.....	.10
Didymium, powder	5.00	5.50	9.00	Silicon, crystal	1.00	1.12	.60
Erbium-Yttrium	10.00	10.00	10.00	Strontium, electrol	7.00	7.25	14.50
Gallium	105.00	105.00	21.00	Strontium, ex amalgam	3.00	3.25	6.50
Germanium, metallic	37.50	37.50	75.00	Tantalum	4.50	4.75	9.50
Germanium, powder	35.00	35.00	70.00	Tellurium, metallic (per 10 grams)	2.00	2.12	.50
Glucinum, powder	6.75	7.00	12.00	Tellurium, precipitate	.....	.20	.18
Glucinum, crystalline	10.50	10.75	21.50	Thallium (per 10 grams)	.37	.37	1.50
Indium	5.00	5.50	9.00	Titanium	1.00	1.12	1.50
Iridium, metallic	1.37	1.25	2.50	Uranium	.75	1.00	2.00
Iridium, in grains	.....	.....	.50	Vanadium	4.00	4.00	7.00
Lanthanum, powder	5.75	6.30	12.00	Tungsten pure (per 100 grams)	5.00	5.00	10.00
Lanthanum, electrol	10.50	11.00	.....	Tungsten com. (per 100 grams)	.....	.....	.40
Lithium, metallic	5.00	5.00	8.00	Zirconium, scales	2.37	2.12	3.25
Lithium, wire	6.25	6.25	.....	Zirconium, powder	2.00	1.62	4.00

With a few exceptions, which will be readily recognized, the metals in this list can hardly be said to be of any commercial value, at any rate in their metallic form. Boron has been suggested for use in alloys of iron and steel, but so far its employment is quite experimental. Manganese, as is generally known, has extensive use in steel manufactures and in chemical works, but is not used in the metallic shape. Of most of the others only very small quantities are ever required or prepared. We add below some notes on experiments made with different metals during the year, with other information concerning some of them.

Cadmium.—The production of this metal is confined to Germany. It is produced in Upper Silesia in a few localities; one establishment turns out about three-quarters of the total. The following table shows the production since 1890.

PRODUCTION OF CADMIUM IN UPPER SILESIA. (*a*)

Year.	Kilograms.	Value.	Year.	Kilograms.	Value.
1890	4,158	$3,653	1892	3,200	$2,850
1891	2,849	2,517	1893	5,284	5,461

(*a*) From *Statistik der Oberschlesischen Berg- und Hüttenwerke*, published by the Oberschlesischen Berg- und Hüttenmännischen Verein.

Cadmium is not used in its metallic form, but with lead, tin and bismuth it forms alloys which are useful for some purposes on account of their low fusing point. Cadmium sulphide is used in making certain colors, while cadmium sulphate and cadmium iodide find limited uses in medicine and photography.

Molybdenum.—Until recently this metal was considered as infusible by any known means. The pure molybdenum, however, is easy to melt in the electrical furnace. The gray oxide obtained by igniting ammonium molybdate is mixed

with sugar and is heated with a current of 350 ampères and 70 volts for 7 or 8 minutes. The button of cast metal thus obtained is nearly pure; several specimens on analysis were found to contain 9.8% to 9% carbon. The metal suffers no change in moist air and shows no evidence of oxidation under ordinary conditions. It is very hard, scratching glass. Some further experiments are now in progress.

Platinum.—No new deposits of platinum have been reported during the year, and Russia continues to furnish the principal supply of this metal. It is again reported that platinum has been discovered in connection with gold in the placers of the Caribou and Kootenay Rivers in British Columbia, but no shipments have so far been made from those districts. A discovery of platinum was also reported early in the year from Wyoming, but the report has not been verified by any actual recovery or shipments of the metal.

Platinum drift has lately been discovered in the New England district, New South Wales, according to Mr. E. Govett, and some of the miners make a good living by washing it out, the crude metal bringing 16s. per ounce locally. This is a very low price, but the storekeepers who are the chief purchasers claim that the price is so uncertain that they are bound to have a fair margin for loss. About 10 miles from Broken Hill there is a huge deposit of ferruginous sandstone containing metallic platinum in very finely disseminated form, but although under assay the stuff yields from 1 to 3 oz. per ton, all attempts to profitably work the deposits have failed.

Titanium.—In the course of his experiments with the electrical furnace, M. Moissan has at last succeeded in obtaining pure titanium in a metallic state. It is the most refractory metal with which he has yet dealt, having an exceedingly high melting point and being less fusible than chromium, molybdenum, tungsten, uranium or zirconium. Like most metals of this group it is extremely hard and is even capable of scratching diamond. It is soluble, however, in molten lead, copper and iron.

Tungsten.—No changes have taken place in the production or uses of this metal during the year; the demand, especially in this country, was light, owing to the depression during the greater part of the year of the industries in which this metal is employed. In the pure metallic state the metal is considered only as a curiosity. Its chief use is in the manufacture of tungsten steel, and for this purpose it is used in the form of ferro-tungsten, carrying about 40% of the last named metal. The minerals from which it is obtained—scheelite and wolframite—are mined in Europe chiefly in Saxony, in Bohemia, and in Cornwall in England, while some ore is also mined in New Zealand and Australia. For several years the production has not varied greatly from 500 tons yearly, of which about 350 tons were obtained in Europe. Imports into the United States have varied from 30 to 50 tons, usually of wolframite carrying about 50% of metal.

While the consumption last year was light we are informed that since the beginning of the year the demand has increased considerably. It is said also that arrangements are being made to develop a deposit of wolframite in this country which will not only supply all that is needed here, but furnish a considerable surplus for export. Besides the ferro-tungsten a small amount of metal

nearly pure is made and sold, chiefly for use in the preparation of tungstate of soda.

The use of this metal in this country is small compared with that the German manufacturers make. For instance, at the Krupp works about 75 tons of tungsten are used yearly in the manufacture of guns, and even in steel rails a small quantity is used; the effect being to produce a very dense, tough and strong steel, with excellent wearing and resisting qualities. The German government has experimented considerably with pure tungsten added to lead in the manufacture of bullets, as it produces a bullet with much higher penetrating power than ordinary lead and yet does not interfere with the fusibility of the metal. Nearly all of the crucible steel makers in Sheffield use tungsten to a greater or less extent; while Osborne & Company, the manufacturers of the "Mushet" steel in Sheffield, have perhaps used tungsten longer than any other steel concern.

To the information concerning the preparation of the pure metal contained in THE MINERAL INDUSTRY, Vol. II. pp. 615–618, we may add the following extract from an article by Mr. Henri Moissan in *Comptes Rendus* for August, 1894: "The metallic powder obtained by the reduction of tungstic acid at a red heat has hitherto been melted only with great difficulty. The preparation of tungsten, either as a carbide or pure, is effected with great ease in the electric furnace. The mixture of tungstic acid and charcoal is placed in the crucible of the furnace, and in about ten minutes, with a current of 350 ampères and 70 volts, we obtain a metallic regulus of about 120 grams. If we take the precaution of adding a large excess of oxide, we may obtain in the first experiment the pure metal. But it is preferable to prepare at first a metal slightly carbureted, and to remelt it in a second operation in presence of a large excess of tungstic acid. Under these conditions we obtain a brilliant metal, very hard, and of a specific gravity of 18.7. This metal has the curious property of fixing a great quantity of carbon. If tungsten is prepared in presence of an excess of carbon, with a current of 1000 ampères and 70 volts, cast metal containing from 17% to 19% carbon is readily obtained."

The following table shows the production of wolfram ore in Europe since 1890:

PRODUCTION OF WOLFRAM ORE IN EUROPE. (IN METRIC TONS.)

Year.	Cornwall.	Saxony.	Bohemia.	Spain.	Total.
1890.....	106	36.650	37	.....	179.65
1891.....	140	42.045	56.70	19.70	257.915
1892.....	127	37	71.90	26	261.90
1893.....	22.35	42.295	42.7	19	126.345

Concerning tungsten in the Australasian colonies, Mr. E. Govett furnishes the following notes:

In New South Wales tungsten ores are found in the New England district and in the Barrier district. In these places the deposits of wolfram are of a similar character, but very little work has been done to test them, and at this time the Barrier is entirely neglected, while only a few tons of wolfram are

annually raised in New England. The wolfram occurs in coarse fragments associated with quartz and mica, with feldspar occasionally present. There do not appear to be any defined lodes, though the rocks containing the mineral have a regular course. At the Barrier the wolfram is found close to the Euriowie tin field where, strange to say, the tin is generally free from wolfram, while in New England the tin veins adjoining the wolfram deposits are entirely free from tungsten.

In Tasmania a wolfram vein has been worked near Waratale to a depth of 70 or 80 ft., when workings were stopped owing to want of capital to cope with water. Scheelite is also present in this mine, where there is also a large quantity of pyrites. When worked the ore was hand broken and picked.

In Victoria in October, 1894, the report of the discovery of an immense wolfram lode about 30 miles from Omeo came to hand, but nothing has yet been done to prove the deposit, the owners resolving to float it in London if possible.

In Western Australia gold prospectors have come across occasional wolfram finds, but beyond forwarding samples to Melbourne for analysis have gone no further.

In New Zealand a little scheelite is produced, but little has been understood about the mineral.

The difficulties experienced in dealing with tungsten ores have not conduced to the exploitation of wolfram properties in any of the Australasian colonies. The mineral undoubtedly exists over large areas, but capital is necessary to prove whether the deposits are payable or not. The price in Melbourne and Sydney from January to October was about £17 10s. for 60% wolfram and £19 10s. for 60% scheelite, but at the end of October it fell about 10%, and the minimum grade was raised to 65%. The number of buyers in the whole of Australia is only three.

As to prices of tungsten, the latest quotations from the manufacturers are as follows: Tungsten, 98% pure metal, 70c. per lb.; tungstic acid, 45c.; tungsten salt (tungstate of soda), 30c.; ferro-tungsten, in ton lots, 33c. per lb. for 37% tungsten; 45c. per 50% alloy, and 60c. for 60% alloy.

Vanadium.—This metal, like titanium, has a very high point of fusion and has been reduced with great difficulty. The cast metal then obtained, however, contains as much as 25% of carbon. In experiments the oxide mixed with sugar-charcoal is reduced and fused to a carbide in the electrical furnace. It requires a current of 1200 ampères and 80 to 90 volts for this purpose.

SALT.

SALT is an article of such prime necessity and so widely distributed that its production is subject to fewer fluctuations and increases more nearly in the ratio of population than that of any other article known to the mineral industry. It is true that some development in the production has come with the growth of the chemical industry in this country, and the demand for it will further increase when the electrolytic processes for producing soda and chlorine come into use.

The following table shows the production of salt in the United States for the five years from 1890 to 1894 inclusive. For the years prior to 1890 statistics will be found in THE MINERAL INDUSTRY, Vols. I. and II.

PRODUCTION OF SALT IN THE UNITED STATES BY STATES AND TERRITORIES.

(In barrels of 280 lbs.)

Year.	California.	Illinois.	Kansas.	Louisiana.	Michigan	Nevada.	New York.	Ohio & W. Va.	Utah.	Other States.	Total Barrels.	Total Short Tons
1890..	62,363	.....	882,666	273.553	3,837,632	.....	2,532,036	461,241	427,500	300,000	8,776,991	1,228,779
1891..	200,000	.....	1,000,000	221,430	3,927,671	15,000	3,532,600	672,000	465,000	200,000	10,233,701	1,432,718
1892..	235,000	60,000	1,232,850	192,850	3,812,054	20,000	4,400,000	738,000	900,000	*b*225,000	11,784,954	1,649,894
1893..	312,850	65,000	1,607,000	172,500	*c*3,514,485	7,988	4,413,181	*a*925,620	438,002	*b*182,435	11,639,081	1,629,471
1894..	324,623	50,000	907,000	185,950	3,485,428	3,957	4,969,694	*a*775,100	453,422	347,801	11,502,975	1,610,416

(*a*) Includes the production of Pennsylvania. (*b*) The production of Texas was 120,000 barrels in 1892, 144,435 in 1893, and 276,857 in 1894. (*c*) Amount inspected.

It will be seen that the decrease in production in 1894 as compared with 1893 was only about 1%, while as compared with 1892, when the production reached the highest point on record, the diminution in output was only a little over 2%. New York continues to hold the first rank as a salt producer, furnishing about 43% of the total, Michigan coming second with about 30%. In 1894 the New York production showed an increase of 556,513 barrels, or 12½%, in spite of the decrease in the total. Michigan, on the other hand, showed a small decrease, while in Kansas the production fell off by about 700,000 barrels. This last result was probably due to the competition of the Michigan salt producers in the central West, and to the increased output in California and in Utah supplying the demand in the Rocky Mountain States and the Pacific Coast. The Louisiana production increased slightly, but no great development is reported in the

immense salt deposits of that State. The imports of salt into the United States show an increase; they were 166,470 short tons in 1893 and 210,613 tons in 1894.

The following table shows the production for 1893 and 1894 in fuller detail, and with values:

SALT PRODUCTION IN THE UNITED STATES.

(In barrels of 280 lbs.)

States.	1893. (a)					1894.				
	Evaporated.	Rock Salt.	Total Barrels.	Value. Total.	Value. Per Bbl.	Evaporated.	Rock Salt.	Total Barrels.	Value. Total.	Value. Per Bbl.
California	309,280	3,570	312,850	$137,962	$0.44	316,623	8,000	324,623	$113,625	$0.35
Illinois	65,000	.....	65,000	52,000	.86	50,000	.....	50,000	40,000	.80
Kansas	1,292,000	315,000	1,607,000	948,130	.59	607,000	300,000	907,000	544,200	.60
Kentucky	36,900	.....	36,900	22,500	.60	34,400	.....	34,400	22,500	.65
Louisiana	.....	172,500	172,500	96,320	.56	.....	185,950	185,950	104,134	.56
Massachusetts	1,100	.....	1,000	990	.90	830	.....	830	760	.91
Michigan	3,514,485	.....	3,514,485	2,108,691	.60	3,485,428	.....	3,485,428	2,091,257	.60
Nevada	7,988	.....	7,988	7,029	.88	3,957	.....	3,957	3,007	.76
New York—										
Onondaga District	613,181	.....	613,181	214,613	.35	645,451	.....	645,451	225,907	.35
Warsaw District	2,428,570	.....	2,428,570	850,000	.35	2,521,843	.....	2,521,843	882,645	.35
Rock salt	.....	1,371,430	1,371,430	370,286	.27	.....	1,802,400	1,802,400	486,648	.27
Ohio	427,320	.....	427,320	256,392	.60	419,200	.....	419,200	255,772	.61
Pennsylvania	255,300	.....	255,300	153,180	.60	125,700	.....	125,700	79,192	.63
Texas	144,435	.....	144,435	115,548	.80	276,857	.....	276,857	230,000	.83
Utah	364,860	73,142	438,002	144,206	.60	407,850	45,572	453,422	155,141	.33
Virginia	.....	.....	.....	.....	.....	35,714	.....	35,714	17,142	.47
West Virginia	243,000	.....	243,000	145,800	.....	230,200	.....	230,200	145,026	.63
Total barrels	9,703,419	1,935,640	11,639,061	$5,623,647	$0.48	9,161,053	2,341,922	11,502,975	$5,396,956	$0.47
Total metric tons	1,232,392	245,838	1,478,230	.....	.....	1,163,508	297,438	1,460,946	.....	.....
Total short tons	1,009,155	275,939	1,629,470	.....	.....	1,282,597	327,869	1,610,276	.....	.....

(a) Statistics for the year 1893 as published in THE MINERAL INDUSTRY, Vol. II., have been revised and corrected by information which was not then available.

New York.—The salt wells of New York still continue the property of the State and are worked by lessees, the constitutional amendment permitting the State to sell the wells in fee having failed to pass. Concerning the salt deposits of New York, Mr. F. J. H. Merrill furnishes the following information:

The salt industry of New York is of great importance. Originally Syracuse was the center of this industry, but since the discovery of rock salt in and near the Genesee valley, from which richer brines can be obtained than at Syracuse, the productive center has been transferred to this new district, and the manufacture of salt at Syracuse is gradually diminishing.

SALT PRODUCTION OF THE CHIEF COUNTRIES OF THE WORLD. (a) (IN METRIC TONS.)

Year	Algeria.	Austria	Canada.	France.	Germany.	Greece.	Hungary.	India.	Italy.	Russia.	Spain.	United Kingdom	United States.
1890	23,974	304,084	39,704	842,529	1,049,644	18,000	159,912	1,052,849	26,978	1,388,365	615,727	2,182,045	1,113,148
1891	34,665	301,422	40,854	810,675	1,170,179	19,772	162,788	1,032,268	40,543	1,351,187	.....	2,077,072	1,299,762
1892	13,000	288,424	41,254	974,000	1,167,264	21,660	179,744	.....	23,721	.....	400,000	1,988,024	1,496,771
1893	19,008	306,856	56,539	1,114,000	1,168,310	18,329	157,209	.....	25,392	.....	361,000	2,015,027	1,478,230
1894	.....	.....	.....	.....	1,253,026	21,310	.....	.....	.....	.....	.....	.....	1,460,946

(a) For Austria, Hungary, Russia and Spain the production of all kinds of salt is given; Germany, rock salt and common salt; Greece, sea salt; France, rock and sea salt; Algeria, rock salt; Italy, rock and salt from brine; United Kingdom, rock and brine salt; India, salt which is liable to British salt tax only, and does not include salt made in certain native States.

SLATE.

But little is to be added at present to the full account given in the previous volumes of The Mineral Industry with regard to the occurrence and quarrying of slate in the United States. The only new deposit of slate which was reported during the year was in Minnesota, where a discovery is said to have been made of a quality equal to any yet found east of Pennsylvania. This new deposit, however, has not yet been opened to any extent or explored, so that its value is still uncertain.

The following table shows the production of slate in the United States by States and districts for 1893 and 1894:

SLATE PRODUCTION IN THE UNITED STATES.

States.	1893.				1894.			
	Roofing Slate.		Other Manufactures.		Roofing Slate.		Other Manufactures.	
	Squares	Value.	Sq. Ft.	Value.	Squares	Value.	Sq. Ft.	Value.
California	3,300	$23,100	.....	.....	3,400	$22,400	.....	.....
Georgia	6,450	29,250	.....	.....	5,000	23,250	.....	.....
Maine	18,712	94,272	41,000	$6,150	17,347	87,082	36,000	$5,350
New Jersey	400	1,600	.....	.....	.....	.....	.....	.....
Bangor region, including the Pen Argyl and hard-vein sections of Pennsylvania	293,466	953,607	251,734	34,036	248,507	815,689	772,315	88,372
Lehigh region, including Walnutport and Danielsville sections, Pennsylvania	146,602	476,502	2,205,746	186,644	113,345	361,971	2,658,810	166,156
Peach Bottom region, Pennsylvania	29,500	146,347	.....	.....	32,248	164,055	.....	.....
Vermont and New York region, comprising Rutland Co., Vt., and Washington Co., N. Y.	256,550	1,040,106	1,575,340	236,301	212,622	850,312	1,536,166	220,400
Utah	60	300	100	50	.....	.....	.....	.....
Virginia	48,847	191,811	65,000	12,500	61,475	226,500	96,500	19,300
Total	803,887	$2,956,895	4,138,920	$475,681	693,944	$2,551,259	5,099,791	$499,578

The table shows that the business depression affected to a serious extent the production of roofing slate, the total having fallen off 109,943 squares in quantity and $405,636 in value. On the other hand there was a considerable increase in the quantity of slate used for other purposes, although not quite enough to counterbalance the loss in roofing slate. There is a steady increase in the demand for slate for blackboards, school slates, billiard-table boards, and for so-called marbleizing and other ornamental purposes.

By far the larger quantity of slate is furnished by Pennsylvania, where the two principal producing districts, the Lehigh Valley region and the Bangor or hard-vein slate quarries in the Delaware Valley, produced together very nearly one-half the slate marketed in the United States. The Peach Bottom region, in southern Pennsylvania, is increasing its output.

Next to Pennsylvania the largest slate region is found in southeastern Vermont and in the adjoining counties of New York. Slate from this district is especially valued on account of its color. The Vermont quarries and those in Washington County, New York, furnish a large quantity of green and red slate which is in demand for roofing and other purposes; and this variety is specially adapted to the marbleizing purpose.

In the Vermont-New York district not much new development is reported for 1894. The Vermont Slate Company combination, which included nearly all the producers of the sea-green slate, and which was dissolved in 1892, has not been reorganized, but the producers have, nevertheless, been successful in fairly maintaining the price.

In the Pennsylvania districts the chief developments of the year were in the opening of factories and the extension of the business of preparing slate for other than roofing purposes. Pennsylvania furnishes the largest amount of slate used for blackboards, school slates and in similar applications, and its preparation and manufacture into these forms is an important industry.

The production of slate in Maine showed very little difference in totals, but there were quite a number of changes caused by the shutting down of some quarries and the opening of others. The Maine slate is of good quality, but its area is comparatively limited.

The Virginia quarries showed a steady increase in the production, as they had done for several years prior to 1893. While the output does not yet compare with that of Pennsylvania or Vermont, Virginia is nevertheless the third State in rank as a slate producer. The Georgia production does not increase and no new work is reported outside of the single quarry in operation in that State.

The only other Eastern States in which slate is quarried is New Jersey, where some outcroppings are found on the continuation of the same range as that on which the Bangor district in Pennsylvania is situated. Some of these have been tested from time to time, but the only quarry in the State which has produced slate commercially is situated near Newton in Sussex County, and this quarry was not in operation in 1894.

A small amount of slate was taken out in Utah in 1893, but none is reported for 1894. The deposits of slate there are said to be valuable and will doubtless be worked when proper transportation facilities are secured. In California a single quarry maintains its output, but no additions are reported.

Little or no slate is imported, the home consumption being sufficient to supply all the demand, while the material is not of sufficient value in comparison with its bulk to support heavy transportation charges.

We are indebted to the *American Slate Trade Journal* for much information in relation to the trade.

STONE.

THERE is no branch of the mineral industry which is carried on more extensively and in a greater variety of ways than the quarrying of stone and its preparation for use in buildings or on roads. This fact makes it one of the most difficult of the industries to estimate accurately or obtain statistics for. In cases where extensive operations are carried on, as in the granite quarries of eastern Maine and of Cape Ann in Massachusetts, the brownstone quarries of Connecticut, or the oölitic limestone quarries of Indiana, the production can be ascertained with comparative accuracy; but outside of such well-known centers of the industry there are found a great number of small quarries where stone is taken out, regularly or irregularly, to meet local demands, and where in many cases the proprietors or operators themselves are unable to determine definitely the quantity or value of their production. In many cases these small quarries are worked at varying intervals and by different persons. A considerable proportion of the building stone used locally comes from these small operations. In addition to this there is stone produced from workings which hardly deserve the name of quarries, and in many neighborhoods are found places where buildings, sometimes of considerable size and importance, have been constructed of stone taken out upon the spot. Under these circumstances only the most general estimates of total values are possible, and any pretense of furnishing exact figures must necessarily be misleading. In certain classes of stone and quarry products, however, we have definite figures of production, which will be found in the special articles following under this head. The total value of the building stone quarried in the United States in 1892 was probably about $45,000,000. In 1893 the production of stone fell off in value, being reduced to about $40,000,000, owing to the closing down of many quarries and the withdrawal of contracts after the commencement of the panic in June, and a general decline in prices. In the early part of 1894 business continued in the same depressed condition as in the second half of 1893. No new quarries were opened and many of the older ones remained closed. After July, however, a gradual revival of business began to be manifested. This was especially the case in the Western limestone quarries and in the granite quarries along the Atlantic Coast. In the latter a gradually increasing output was reported, more especially in paving blocks and in stone for bridges and other public works, and at the close of the year business had begun to approach its

normal condition. The stone production of 1894 probably did not vary much from that of 1893, and in fact exceeded it a little, but the value was about the same, any increase in quantity being counterbalanced by a decrease in prices.

A growing demand for stone, of which little notice has heretofore been taken, is springing out of the movement for better roads, and the consumption of broken stone for this purpose is increasing rapidly. Not every local stone deposit is suitable for this purpose, and in cases where cheap water transportation is available it is carried a considerable distance. Thus the magnesian limestone from the Hudson River Highlands is distributed all along the river and Long Island Sound, and is taken to the cities on the line of the Erie Canal; while granite from Maine and Rhode Island finds its way into the pavements of all the cities on the Atlantic Coast and even as far as Galveston on the Gulf. This class of material, however, will not bear heavy transportation charges, and its shipment to interior points where rail carriage is necessary must be comparatively limited. It is only where a special material is required for city pavements, such as the bluestone of New York and Pennsylvania, or the flagstone of Kansas and Colorado, that distribution to any considerable distance from an inland quarry is possible.

For building stone of the finer qualities, where a greater expenditure is warranted by the purpose to which it is applied, the radius of transportation is much greater. Thus, for instance, the oölitic limestone quarries of Indiana have supplied a large part of the material used in the better class of buildings in Chicago, St. Louis, and even more distant cities, and the Berea stone of Ohio is found in many interior cities. As the value of the product increases and its adaptation for special purposes is greater, the distance at which it can be marketed increases. The Vermont and Tennessee marbles, which are used in comparatively small quantities for decorative and monumental purposes, are carried all over the country.

While the depression in the stone industry naturally prevented the opening of new quarries and the extension of works in older ones, something was done in this direction, though chiefly in the second half of the year. Some new granite quarries were opened in Maine and in western Massachusetts; and in northern New Jersey the revival of the industry was stimulated by the discovery of a valuable bed of pink granite in Sussex County. Similar instances could be cited from other States.

The prospects for 1895 are for a gradual revival of the stone industry, the signs of which are already apparent.

Building Stones of Missouri.

According to Dr. Charles R. Keyes, State Geologist, Missouri is well supplied with stone suitable for all kinds of building and construction purposes. These include standstone, granite, and a large variety of limestones and marble, besides onyx and other kinds suitable for ornamental work.

The limestones are the most abundant and occur in over half the counties of the State. There are a number of varieties, including the ordinary gray stone, the white semi-crystalline and dolomite. They are already worked in many places

and the occurrences are so located, with reference to transportation to markets, that large additions will probably be made to the quarries operated.

Sandstones are numerous and in many places of excellent quality, producing material that has been used widely and in many important buildings. The best stone and the largest quarries yet opened in the eastern part of the State are in St. Genevieve County. In the western part of the State there are extensive quarries of hard sandstone in Johnson County.

Some large deposits of marble have been found in the southwestern part of the State; stone taken from these beds is compact and takes an excellent polish. The color varies from gray through pink, brown and red to black, and some specimens found are beautifully veined and marked. With better transportation facilities these marbles will doubtless be worked extensively.

Recently deposits of onyx have been discovered in Missouri which appear to be of a good quality. The stone presents a great variety of colors from yellow to very dark brown. It is usually translucent and capable of a high polish.

Building Stones of New York.

By F. J. H. Merrill.

In the variety of its building stones New York is prominent. Since a greater variety of geological systems is represented within its limits than in those of any other State, the variety of its building stones is greater. Nearly every geological stratum furnishes one or more varieties of stone which are useful in building. The product of the New York quarries may be divided into dimension stone, flagstone and roofing slate. From many of the quarries which furnish these materials there are also produced road metal and paving blocks.

Among the building stones of New York which are most widely known are the red granites of Grindstone Island, in the St. Lawrence River, and the dark green granite, or norite, of Keeseville. Next in geological order are the Potsdam sandstone, quarried extensively on the north flank of the Adirondack wilderness, and the Trenton limestone in its various subdivisions. Under the name of Lake Champlain bluestone the Chazy limestone is quarried at Willsboro Point. At Glens Falls a very good black marble is quarried from the Trenton, and in Jefferson County and along the Mohawk Valley there are many quarries.

The Medina sandstone is so well known as to require no detailed mention. The Niagara limestone is quarried at Rochester and Lockport, whence the well-known Lockport marble is derived. The Helderberg limestones are quarried at many points; among the most important of these are Cobleskill, Onondaga, Auburn, Waterloo and Buffalo. The sandstones of the Hamilton and Portage groups, known throughout the country as "Hudson River bluestone," are quarried extensively in Ulster and Sullivan Counties. Also, under the generic name of "bluestone," in Delaware, Chenango, Livingston and Wyoming Counties. Flagstones are produced extensively in Ulster and Sullivan Counties from the strata which yield the so-called "bluestone." The Chemung and Catskill groups yield many good sandstones, and are chiefly quarried in the southern tier of counties from Sullivan westward. Prominent localities are Waverly, Elmira, Corning, Dansville, Bath and Olean. The Triassic sandstone is quarried in Rockland County, but chiefly for local use. It was formerly used largely for

building in New York City, but has been superseded there by the Connecticut brownstone.

The Cambrian slate of Washington County is widely exported. The chief quarries are in the vicinity of Middle Granville, Hebron and Salem, and slate is produced for all commercial purposes.

The marble from the quarries of Tuckahoe in Westchester County has been used in many buildings in New York City, but has now been superseded to a large extent by Vermont marble.

Millstones.—In the western part of Ulster County the hard quartzose conglomerate of the Oneida group is quarried extensively for millstones, which are used chiefly for grinding mineral paints, feldspar and similar substances. The industry is said to amount to about $100,000 a year.

Road Metal.—The rocks used for road metal in New York State are diabase (trap), granite, gneiss, limestone, sandstone, shale and gravel. Many of the local stone quarries which are scattered over the State sell for road metal the rock obtained in stripping off the upper layers from their quarries, but there are a few large quarries which are operated for obtaining road metal alone and which deserve special mention. Many tons of material are quarried annually from the Palisades range near Piermont. The material, which is exceedingly tough, is either dressed for paving blocks or crushed for road metal. Further up the Hudson River the limestone quarries of Tomkins Cove have been in operation for a number of years and supply large quantities of rock for macadam. It is one of the best materials used. This magnesian limestone is hard and packs easily, and makes a good surface, but the cost of maintenance is considerable. The following is an analysis of this stone: Lime, 60.20%; alumina, 11.22%; silica, 6.13%; magnesia, 10.45%; carbonic acid, 8.00%; water, 4.00%.

At Iona Island a granite is quarried and crushed to five or six different sizes for road metal and concrete. The fine residue or dust is sold for polishing. The Hudson River Stone Supply Company has an extensive plant for quarrying and crushing granite, at Breakneck Mountain, north of Cold Spring. The same company operates a second plant for supplying crushed limestone at Stonecho, north of New Hamburg. One of the largest quarries in the State is that of P. Callahan at South Bethlehem, Albany County. The lower Helderberg limestone is the rock used and it makes a good road. The Caudagalli grit of Albany County is used in small quantities locally and makes an excellent road, though it is not very durable. At Duanesburg, near Schenectady, sandstone of the Hudson River group is crushed for road metal. At Portchester, in Westchester County, a coarse-grained granite is quarried, and is considerably used locally, but the best macadam roads of that district are of limestone from Tomkins Cove. The gray gneiss has been considerably used as a road material in Westchester County, where it is abundant; it makes a good road, but wears down rapidly, requiring frequent renewals. The waste from the Tuckahoe marble quarries has been used in their neighborhood over a number of miles of road. On Staten Island the yellow gravel is much used for road-making. The diabase or trap from the Graniteville quarries is being extensively used on a system of country roads with the most satisfactory results.

Flagstone.

By David P. Jones.

The deposits of natural flagstone, so far discovered and worked in the United States are three in number: The North River bluestone of eastern New York and Pennsylvania, the red flagstone of Colorado, generally called Fort Collins or Lyons stone, and the Kansas flagstone, commercially known as Fort Scott and Bandera stone.

North River Bluestone.—This is a stone of excellent quality, and is not injuriously affected by changes of temperature or climatic conditions. In this respect it differs from many varieties of stone, which are durable in certain climates, but in other localities will disintegrate rapidly. This stone is widely distributed throughout the Catskills and the eastern slopes of the Alleghenies. The deposits are generally in slightly inclined beds. While very large stones are quarried, no single quarry can be relied on to furnish a great number of stones of specific sizes; but it is found over a large area of territory, and there are always workings enough to supply the demand for slabs of any required dimensions.

This North River bluestone from New York and Pennsylvania is the recognized typical flagstone in all the towns and cities of the New England and Middle States. It is occasionally shipped by rail as far west as St. Louis and Kansas City, and is frequently carried by water to Galveston and other Southern cities.

In general it may be said that the profitable shipping radius of flagstone, by rail, is about 700 miles. Beyond that distance the freight charges would make it too costly a material. The only exception to this rule is the Kansas flagstone, which is shipped as far as 900 miles. This is owing to the cheapness with which it can be quarried.

It is exceedingly difficult to obtain statistics of the production of bluestone owing to the scattered nature of the deposits and the number of small quarries which are worked irregularly, and from which no returns can be obtained. In 1892 the value of the output was estimated at $1,600,000, and in 1893 this had fallen to $1,000,000. For 1894 the production was probably a little greater than that of 1893, as there was a slight increase in demand; but as prices ruled low the value was about the same.

Colorado Red Flagstones.—The Fort Collins and Lyons deposits in Colorado are sandstones of a very hard variety, and furnish flagstones of excellent wearing qualities. Near Fort Collins two varieties are found—one a dull white and the other a light pink in color. The Lyons stone is of a dull red color. The thinner layers of the Fort Collins stone—under 3 in. in thickness—are often stratified, and much of it is unfit for use. The heavier layers, while showing lines of apparent stratification, do not disintegrate, and the stone is fine and durable. The Lyons stone is handsome in appearance and of excellent quality. In some cases, when laid near alkali soil, it has been found to disintegrate from the action of the alkali.

The Colorado flagstone is found in layers of varying thickness, associated with a heavier grade of building stone. It is usually difficult to quarry it in quan-

tities, to specific dimensions, on account of the seams in the quarries and in the layers of the stone. Moreover, the thickness of the slabs is not uniform; stones from 6 ft. to 8 ft. in length frequently vary in thickness from 2 in. to 3 in. Very large single stones are occasionally quarried—one sent to the Columbian Exposition at Chicago was 8 ft. by 16 ft.—but they are the exception and not the rule. The Colorado flagstones are extensively used west of the Missouri River, the chief drawbacks to their general employment being the high rates of freight and the difficulty of securing many large slabs of uniform thickness.

Kansas Flagstones.—The deposits of natural flagstones in eastern Kansas are the largest workable beds of this kind of stone in the United States. While they occur over a smaller superficial area than the North River bluestone, the beds or layers are deeper; in general they can be quarried easily and at a low cost, while the facilities for drainage are good. They are usually free from seams, so that stones of large size can easily be quarried. The stone is found in horizontal strata of uniform thickness and considerable extent; it is usually of a light steel-blue color, though some beds are brown or gray. It is a fine-grained sandstone, containing a small percentage of calcium carbonate, in quality very similar to the Berea stone of Ohio. When first quarried it is somewhat soft, but hardens by exposure to the atmosphere, and seems to have the quality of resistance to climatic changes that distinguishes the North River stone. The deposits so far found are in a belt extending from northeast to southwest through the southeastern counties of the State. Stone of the same character is found at Warrensburg, in Missouri, but exists there in masses and not in laminæ.

There are two varieties of the Kansas flagstones, the brown or gray, and the blue. The gray is usually overlaid with earth and shale only, while the blue occurs under masses of rock. The bluestone, again, has two sub-varieties, one with a very smooth surface and the other with a rougher face. The smooth variety has a very handsome appearance when quarried, but does not wear well; the slabs are laminated, and the laminæ frequently peel off when the stone is exposed to wear and weather. The rough or mottled stone has a peculiar appearance, closely resembling alligator skin. Under certain conditions the mottlings will wear into shallow holes, called by the quarrymen "wormholes," on account of their peculiar appearance. The wearing qualities of the rough stone are excellent, and it is generally preferred by buyers.

The largest deposits of flagstone yet opened are at Bandera, in Bourbon County, on the line of the Missouri Pacific Railway, 11 miles west of Fort Scott. Deposits exist in other localities, but they are either of limited extent, at a distance from railway facilities, or so located as to be incapable of economical drainage, and are unprofitable to operate.

Flagstone was first quarried in Kansas in 1869, but the early operations were desultory and unsystematic, and it was not until 15 years later that the work was begun on a large scale and in a business-like way. The largest quarries at Bandera are owned and worked by the Bandera Flagstone Company, an incorporated company. There are other quarries in the vicinity, the most notable being the Gilfillan. From these Bandera and Gilfillan quarries is shipped over 90% of the natural flagging used west of the Mississippi. The Bandera quarries

were opened during the spring of 1884; from that time up to July, 1894, the output of flagging, varying from 1½ in. to 5 in. in thickness, was 5,000,000 sq. ft. From the Gilfillan quarries during the same period the shipments amounted to 3,000,000 sq. ft., making a total of 8,000,000 sq. ft. As the average price has been about 10c. per sq. ft. on cars at the quarries, this represents a total of $800,000. If to this is added an estimated average of 4½c. per sq. ft. for freights and 5c. for cutting and laying, the total amount realized for the flagstone in place has been not far from $1,560,000. The freight tonnage furnished the railroads has been approximately 200,000 tons.

The stone from the Bandera quarries has found markets in the principal cities of Kansas, Arkansas, Texas, Missouri, Iowa, Nebraska and Colorado. Its principal use is for sidewalk purposes and for curbing, but a large amount is also used for building—in trimmings, tiling, wainscoting, cemetery vaults, and other purposes. While the general introduction of cement and artificial stone for sidewalks and curbing has reduced the output of flagstone, and materially affected its market price, the quarries are yet taxed to the utmost to supply the demand. The competition of cement is rendered more formidable by the ease with which artificial stone made from it can be slighted in its composition, while the quality of flagstone cannot be altered or cheapened to meet this competition. New uses are being constantly discovered for this flagging material. One use to which it is put by architects is in what is called "Pierpont" work; that is, the stone is made into bricks, with a pitched or rocked face, and is used in veneering buildings, the courses being arranged in thicknesses varying from 1 to 5 in. The cost of this "Pierpont" work in the large cities of the West is about the same or very little above that of pressed brick. Another use suggested by the fine grain of the stone has also been found. It is shaped into bricks of convenient size and sold for household use in whetting cutlery. It does this quickly, and is of such fine texture that it does not "rag" or roughen the edge of a knife. It is claimed that, in addition to its other qualities, this stone is, to a certain extent, refractory, but this is doubtful.

Methods of Quarrying at Bandera.—In this locality the flagstone is found in horizontal layers under a species of conglomerate sand-rock, varying in depth from 6 ft. to 15 ft. After this top rock is blasted off it is generally loaded on cars and sold for railroad ballast at the cost of loading, for the sake of getting rid of it. In the quarries there are 57 ledges of strata of marketable stone, varying in thickness from 1 in. to 6 in. Theoretically this would give a total of 2,257,200 sq. ft. (superficial) of stone per acre, but a deduction of from 20% to 25% must be made for faults, such as seams, "rag," "sticking," and especially what are locally called "hog-backs." The latter are ridges which run through the quarries in various directions, varying in thickness from 4 ft. to 10 ft., and frequently extending from the top to within 12 or 14 ledges from the bottom. In them the layers seem to have been crushed or cemented together, and it is impossible to get any useful stone out of them. At the same time their removal is a cause of considerable expense; they must be quarried out, as blasting would injure the flagstone adjacent. The cause of these ridges cannot be determined.

The layers of flagstone are very even in their thickness, which varies in the

different beds from 1 in. to 6 in. These are not arranged in any systematic order, for some of the thinner flags are found at the bottom. It is to be noted, however, that in all the flagstone deposits yet opened in eastern Kansas the same general order of arrangement and relative position of the layers of different thicknesses is found.

Among the ledges of flagging, at intervals of seven or eight layers, there exists what is termed in quarry language "rag," which is composed of thin layers of shale of a combined thickness varying from 4 in. to 10 in. As the quarrying proceeds in a southwesterly direction these layers of shale thicken and gradually change their soft character until they become of value as flagging. The "rag" is wasted. In removing, it is wedged up with wedges or long flat steel slicers of the form shown in Fig. 1. The process of removing this waste is called "ragging."

As the quarrying proceeds southward many of the layers of flagging are rough, and planing is necessary to make them marketable. In the opposite direction, north and west, the stone improves in surface, and is ready for the market when first taken out. The layers gradually thicken toward the southwest. This

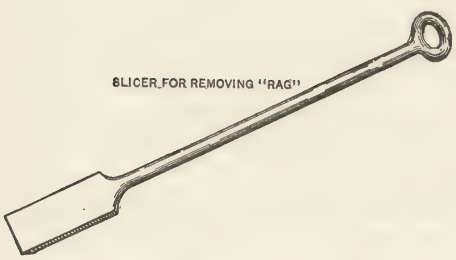


FIG. 1.

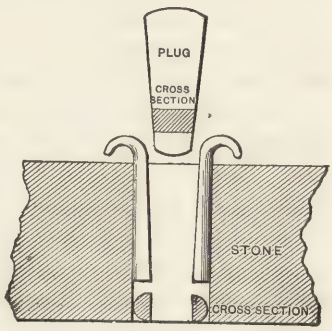


FIG. 2.

APPLIANCES USED IN THE BANDERA QUARRIES.

thickening is from about $\frac{3}{4}$ in. in 100 ft. The planing referred to is done by a machine similar in general design to a large machine planer. The tools are fixed on cutter-heads, and are arranged so as to strike the stone at an acute angle, as this prevents fracture. The bed carrying the stone has an automatic feed-motion, and the cutter-head also moves. The latter carries six cutters or chisels, 2 in. in width; they are tempered to a medium or light blue. Care is always taken to plane the stone as soon as it is quarried, for it is then much softer, and can be planed more rapidly and at less cost. The cutter-head revolves at a high rate of speed, about 2500 ft. per minute. It has a lateral and vertical feed. The high speed gives better and smoother results than a lower speed.

In preparing a "bench" for quarrying, the first step is to remove the top rock. This is done by blasting, and the electric battery is used to fire the blast. Great care is taken not to drill the blast-holes quite down to the flagging; otherwise it would be broken and cracked to a considerable depth by the blast. As soon as the top rock is removed the bench is ready for the quarrymen. Immediately

under this top rock are several layers of fine stone of thickness varying from 1 ft. to 2 ft. This stone is prepared for the market as building stone, being taken out in dimension sizes by the "plug-and-feather" method. In this, as is well known, a series of holes, from $1\frac{1}{4}$ in. to $1\frac{3}{4}$ in. in diameter, are drilled in the stone to a depth of 6 or 8 in. In these holes are placed the feathers, two wedge-shaped pieces of half-round steel; these are shown in Fig. 2, with the plug; the latter is a steel wedge, which is placed between the feathers. A few blows of the hammer on the plug will crack the stone. This method is used for getting out stone of moderate dimensions; larger blocks are more easily taken out, with squared faces, by the Knox system of blasting.

In getting out the flagstone, the first step after a bench is ready for quarrying is to channel down at one side or end. This channel is generally from 6 to 8 in. wide. At the other end there is usually a natural seam, since the quarrying is always carried on so as to utilize all seams in securing a free end for the stone. The channeling is done either by hand or by machine drills. When

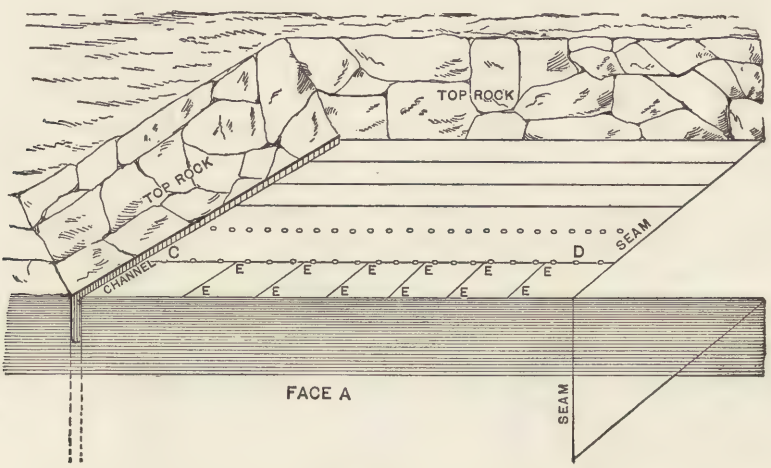


FIG. 3.
METHOD OF QUARRYING FLAGSTONE AT BANDERA.

done by hand it is worked in cuts about 8 in. wide and 12 in. deep; this is the greatest depth possible at a single operation without using a wider cut and increasing the waste. To quarry the flagstone profitably, it should be free on the front face and at each end, leaving the bench in the condition shown in Fig. 3. The seams above referred to as found in the stone, run the entire length of the quarry in straight lines and are in depth equal to the depth of the flagstone. So long as there are not too many of them these seams are great aids in giving a free end to the benches of stone. The bench being prepared, the stone is quarried off to the superficial dimensions required.

Much of the flagging quarried is in 4-ft. widths, and in lengths from 5 to 16 ft. The superficial dimensions are always limited by the thickness. Four feet width are considered a good size for shipment, as the flat cars upon which the stone is generally loaded are about 8 ft. wide, and two layers of stone can be loaded side by side. When the desired width is determined upon, the distance is measured

back from the face *A*, Fig. 3, and a line *C D* is marked on the bench. This being done, the quarrymen pick in the stone with a tool of the form shown in Fig. 5, weighing from 5 to 8 lbs., what they call "plug-holes." These are V-shaped, about 3 in. long and from 1 in. to 2 in. deep. Into these holes are fitted small wedge-shaped, blunt plugs, of the form shown in Fig. 4. The plugs are struck with a light sledge, and this cracks the stone along the whole line of plug-holes, which sometimes extends for 200 ft. When the cracking is done, the quarrymen pry out the long slab in order to free the bottom. This work has to be done carefully, to avoid fracturing the stone or chipping the edges. Men are placed at intervals of about 6 ft. with their bars fitted into the plug-holes, and at a given signal they surge simultaneously upon the bars. The plug-holes for cracking

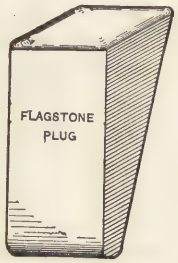
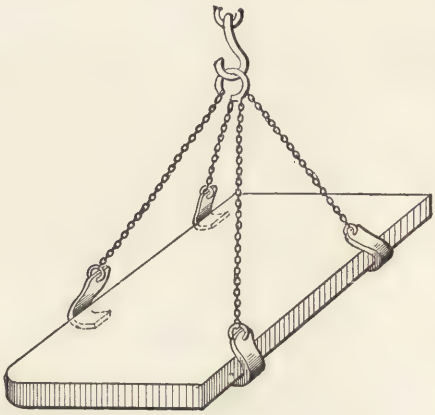


FIG. 4.

FIG. 5.



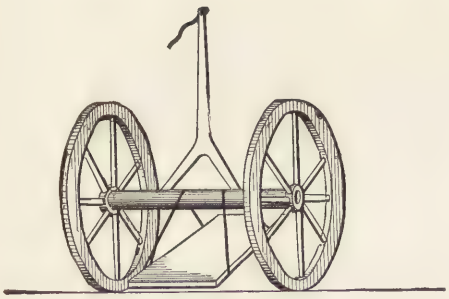


FIG. 8.

FIGS. 6 AND 7.

APPLIANCES USED IN THE BANDERA MINES.

the stone are all made by hand; as no two adjoining layers may be quarried out the same width, it has not been found either expeditious or profitable to use machinery for this work. After the slab is free, the lengths desired for the stone are marked off as shown at *E, E, E*, Fig. 3, and a small score is cut with a chisel or scratched with a sharp steel point. After this is done, by putting a small plug or chisel under each end of the stone, at the score mark, the piece is broken off straight, and is ready for shipment.

Should one layer stick to the other, as frequently happens, great care is taken to separate them. This is done by long thin wedges driven in by light taps. As the stone generally sticks in two or three places, these sticking places are located by tapping on the surface with a hammer. This "sticking," as it is called, is the exception and not the rule in these quarries. It must be remem-

bered that each layer of flagstone is separate and independent from the others. There is no such thing as splitting the stone. The layers separate readily, except for the occasional sticking just mentioned. There is always moisture between the layers.

In lifting the slab of stone by the derricks, peculiar-shaped hooks are used. They are fixed on slings, two on each side. With light stone, two on one side and one on the other, are generally sufficient. Fig. 6 shows the method of slinging the stone, and Fig. 7 shows the form of the hooks. In moving stone in the quarry a hand-crab of the form shown in Fig. 8 is frequently used. The method of using it will be readily understood from the drawing, which shows it in position over a stone, ready to lift it.

In shipping, the stone is piled on a flat car, usually from four to six layers in height. Under each layer, near each of the four corners, are placed bunches of

FIG. 9.—VIEW IN BANDERA QUARRIES, KANSAS.

hay. Different methods have been tried, but this hay-packing has been found to be the only efficient way of preventing breakage when the stone is shipped long distances by rail.

The Kansas flagstone weighs 156 lbs. per cu. ft. It is usually sold by the superficial foot. The following table will show the usual sizes quarried and the quantity that can be shipped on a car of 30,000 lbs. capacity:

Purposes for Which Used.	Thickness of Stone.	Maximum Length of Slabs	Car Load.
	Inches.	Feet.	Square Feet.
Garden walks	1½	4	1,500
Garden and residence	1¾	5	1,300
Residence walks	2	6	1,100
Residence walks	2½	8	900
Residence and business	3	10	750
Business walks	3½	10	640
Business walks	4	12	600
Business walks	4½	13	550
Business walks	5	14	460

Figs. 9 and 10 are from photographs, and give an excellent idea of the general

character of the workings. Fig. 9 shows piles of flagstones just quarried and in course of preparation for shipment. In Fig. 10 men are seen at work on the benches of stone. These engravings will assist the reader in understanding the descriptions given.

It may be remarked that this natural flagstone requires special treatment in quarrying. The dexterity required to handle large slabs of stone, whose superficial area is very great compared with the thickness, is considerable. It is often a matter of surprise to see men of medium build, or undersized, handle huge sheets of stone without fracturing them.

In the Bandera quarries it is not an unusual thing to get out and ship flags from 8 to 10 ft. wide and 18 ft. long, with a thickness of 4½ in. While flagstones of almost any size can be quarried, the dimensions are limited in practice by the thickness of the stone, and by the capacity of the cars upon which they are shipped.

FIG. 10.—VIEW IN BANDERA QUARRIES, KANSAS.

Cost of Production at Bandera.—The average actual cost of removing the top rock is 50c. per cu. yd. This, with 12 ft. of stripping, and with the present number of underlying ledges, reduced to terms of square feet of flagstone quarried, amounts to 0.55c. per sq. ft. This includes labor at 15c. per hour, powder, and the use of tools, besides a short haul for the waste rock.

After the bench is ready, 20 men can easily quarry 3000 sq. ft. of flagging per day of 10 hours, of stone from 2 to 4 in. thick. The wages of the quarrymen are from $1.50 to $2 per day. The best quarrymen receive 20c. per hour, the next 17½c., and the next 15c. The laborers and strippers receive 12½c. per hour. Teamsters receive $35 per month. Teams with drivers can always be hired for $2.50 per day of 10 hours. One man with helper can easily quarry 300 sq. ft. of flagging in one day of 10 hours. If the stone "sticks," that is, if the layers do not separate easily, the amount quarried by the two may be

reduced to less than 200 sq. ft. per day. This makes the approximate cost of quarrying stone 1¼c. per sq. ft., or 0.4c. to 0.5c. per sq. ft. for each inch in thickness. This last is the usual method of estimating and pricing at the quarries. To this amount must be added the handling and loading. The loader is paid 20c. per hour, and his helpers 15c. per hour. A loader, with helper, can load 2000 sq. ft. per day of 10 hours. This amounts to nearly 0.2c. per sq. ft. Then there must be added for the cost of packing hay, the care of teams and superintendence, 0.5c., making the actual cost of the work at the quarry 1.95c. per sq. ft., not including the stripping. To this again must be added general expenses, stripping, repairs, interest on money invested, loss by breakage, amounting to 1.75c. per sq. ft., bringing up the total cost of the stone as loaded on cars to about 3.70c. per sq. ft.

RECAPITULATION.

Cost reduced to terms of flagstone quarried.

	Per sq. ft. of flagstone.
Stripping 12 ft. of rock	0.55 cents.
Quarrying	1.25
Loading on cars	0.20
Superintendence and packing	0.50
General expenses, agencies, materials, tools, repairs, etc	1.20
Total cost of flagging per sq. ft in cents	3.70 cents.

Averaging the various thicknesses quarried, this amounts to 1.5c. per sq. ft. for each inch of thickness; in quarry terms 1½c. per in.

Where the stone has to be planed, the average cost of planing is 1¼c. per sq. ft. for all thicknesses up to 4 in.; this is distributed as follows: Handling, two men, 0.50c.; running planer, one man, 0.50c.; fireman and fuel, 0.25c.—total, 1.25c.

With stone of uniform grain the cost may be as low as 1c.; where stone has been quarried for some time and is hardened by exposure it may be as high as 2c. per sq. ft.

Formerly the prices received for flagstone, loaded on the cars at quarry, ran about 3½c. per in. for each sq. ft.: that was, for the thinner grades up to 2½ in. in thickness. For the heavier grades, up to 5 in., the price was from 4c. to 5c. per in. During this period the wages of the men were higher than they are now. At present the prices received for the stone average but little over 2½c. per in. for all grades of unplaned or "natural surface" stone. This reduction in price has been met by more systematic and improved methods of quarrying.

As the stone is shipped from the quarries in slabs that are known as "broken square in rough," the edges have to be dressed or jointed at the destination. This is done by flagstone layers who make a business of doing this especial kind of work. These men are paid by the square foot. The price usually paid is 5c. per sq. ft. for hauling to place, furnishing a bedding of sand, and cutting and laying the stone. This price is made up as follows: Cutting and laying, 2c. to 2.5c. per sq. ft.; sand-bedding, 1c.; hauling to place, 1.5c.—total, 5c. per sq. ft.

One man, with a helper at $1.50 per day, can cut and lay from 225 to 350 sq. ft. per day, showing average earnings of $7.17 per day, including the helper. Two men have been known to cut and lay 480 sq. ft. per day, showing earnings of $12 per day for the two.

Tests of Flagstones.—Comparative tests of flagstones were made some years ago by John Muckley and J. E. McConnell, under the direction of the Omaha Board of Public Works, the samples being furnished by City Engineer G. W. Tillson. The results are given in the table below:

TEST NO. 1.

No.	Name of Stone.	Crushing Strain Per Sq. In.	Commenced Chipping.
1	Berea, Ohio	6,875 lbs.	31,000 lbs.
2	Bandera, Kan. (Hyland)	10,208 lbs.	43,000 lbs.
3	Gilfillan, Kan	8,500 lbs.	24,000 lbs.

TEST NO. 2.

No.	Name of Stone.	Weight when Put In.	Weight when Removed	Per Cent. Less in Weight.	Relative Value Shown by	
					Crushing.	Rattle.
1	Berea, Ohio	54¾ lbs.	48¾ lbs.	10	3	2
2	Bandera, Kan. (Hyland)	74¼ lbs.	69 lbs.	7	1	1

In test No. 2 four pieces of stone of each kind were placed in a rattler 2 ft. in diameter, together with 10 brake-shoe castings (a new set each time) weighing each 30 lbs., and the drum revolved at the rate of 14.5 revolutions per minute for 20 minutes.

A test of the stone from the average run of the quarry, made at the Watertown, Mass., arsenal, showed a resistance to crushing of 8600 lbs. per sq. in.

Bedford Oölite and Chicago Dolomite.

By T. C. Hopkins.

The Bedford Limestones of Indiana.—The oölitic limestone quarries in Indiana, at Bedford, Ellettsville, Stinesville, Bloomington, Salem and in the surrounding region, is commonly known in the markets as the "Bedford Stone," Bedford being the chief center of the trade. The area of the oölitic stone extends through Lawrence, Monroe, Washington, Owen, Crawford, Harrison and adjoining counties, but most of the quarries are in the first three counties named.

The Bedford stone ranks among the best building-stones in the United States, and the many fine buildings constructed of it in different States attest its well-deserved popularity. Among the structures built of this stone might be mentioned the State Capitol and the Soldiers' and Sailors' Monument at Indianapolis, the numerous buildings of the University of Chicago, the Courthouse in Cincinnati, the Cotton Exchange in New Orleans, and the Cornelius Vanderbilt residence in New York.

The properties that make this stone valuable for building purposes are its great elasticity, pleasing color, durability, ease of working, and its homogeneity of composition and texture, many of the other properties depending on the last. While soft enough to be easily cut it is firm and elastic enough to give a clear metallic ring under the hammer. The tendency of most limestones is to split on lines parallel to the bedding, or at right angles to it, regardless of the direction in which the splitting force is applied; this renders them undesirable for carved or tooled work of any kind. The Bedford stone, however, has the character of a freestone; it splits or cuts equally well in all directions, and is thus suited for work of all kinds. This property was admirably shown in the sample exhibited at the World's Fair representing a hammer, chain, and cogwheel on a blacksmith's anvil, all carved out of one block of the stone. In most places the stone does not occur in thin layers, as do many limestones, but in a massive bed many feet in thickness and with comparatively few joints or cracks, so that it can be obtained at the quarry in blocks as large as desirable.

It is cut from the quarry by channeling and gadding machines, and the blocks reduced to smaller dimensions, when so desired, in the sawmill; planing and jointing machines are sometimes used where a finer surface is desired, and sometimes the carving is done by machinery. The rock is soft and easily cut when first quarried, but hardens on exposure by the loss of the quarry water; yet it never becomes as hard as many of the more crystalline or finer-grained limestones.

The Bedford stone, as shown by chemical analyses, is a comparatively pure carbonate of lime. The following analysis of oölitic limestone from Salem resembles very closely analyses of samples from other localities in the area, and fairly represents the average composition of the stone:

ANALYSIS OF BEDFORD STONE.

	Per Cent.
Carbonate of lime	96.04
Carbonate of magnesia	0.72
Alumina and iron oxide	1.06
Insoluble residue, silica, etc	1.13
Soda and potash chlorides	0.15
Water, loss, etc	0.90
Total	100.00

The rock is composed of small, somewhat irregular, rounded grains, consisting largely of small shells and shell fragments, the bulk of the rockin some places consisting largely of the remains of Foraminifera and small Protozoa which occur in such large quantities in the chalk-beds of England and the European continent. Many of these microscopic shells have a more or less regular spherical form, and it is these which in large measure give the stone its oölitic appearance. Mingled with the Foraminifera are fragments of larger shells with finer detrital material, and some crystallized calcite, which acts as a cement to bind the grains together. Thus, while concretionary structure may not be entirely absent, the stone, in the specimens examined, owes its oölitic appearance to the microscopic globular shells, and not to any concentric or radiated structure such as characterizes most oölites. According to the definition given by some writers, the Bedford stone would not be a true oölite or even oölitic. However, there is good authority for using the term oölite for rocks made up largely of small, rounded, fish-egg-like particles, whether these particles show a concentric or radiated structure or not; but in so using the term it is necessary to keep in mind that it refers to an external appearance and not to the internal structure, and that there are differences in oölites just as there are differences in other limestones. Just as the crystalline limestones or marbles of Maryland may be and are different from the marbles of Georgia, so the Bedford oölitic limestone may be and is essentially different from the Portland oölite or Bath oölite of England, and the oölite from one quarry at Bedford may be quite different from stone taken from another quarry in the same region, although the change will probably be less than that between stones from different regions.

The Bedford stone is eminently suited for building purposes, and for such use it is quarried in large quantities and shipped not only to all parts of the State of Indiana, but throughout the Mississippi Valley, and even into the Eastern States. Chicago and Indianapolis are the chief markets, yet considerable quantities are shipped to Louisville, St. Louis, New Orleans, Cincinnati, Philadelphia, and New York. It has an extensive use in Chicago for trimmings or for stone fronts for brick buildings. The greater part of the better class dwellings and apartment houses put up in that city during 1894 have stone fronts, and the Bedford stone seems to be more in favor than any other. The cutting in prices during the latter part of the year so demoralized the trade that many of the companies ceased shipping. A combination of all the companies in the district has recently been effected, by which the price is to be maintained at 20c. per ft. It is further stated that all the Bloomington quarries are now controlled by a Chicago syndicate.

Statistics of production from six of the leading companies in the district give for 1894 a product of 670,000 cu. ft., valued at $224,640, as compared with 723,500 cu. ft., valued at $246,350, for 1893. As there were about 21 companies in operation during the latter part of 1894, several having suspended operations during the year, this would represent about one-third of the product for the district. Such a result is only approximate, however, and these figures are chiefly valuable as showing the condition of the trade for 1894 as compared with 1893. About 27% of the product for 1894 was shipped to Chicago. This is probably below the average proportion sent to that city, as during the latter part of the

season many of the companies stopped shipping there owing to the exceedingly low prices.

Oölitic limestone of the same age, but varying locally in character, occurs in Kentucky, Illinois, Iowa, Missouri and Arkansas. It is known to be quarried to some extent in Kentucky and Arkansas, and may be worked on a small scale in the other States. The Kentucky stone in some localities is more distinctly oölitic than the Bedford stone. The rounded spherules are larger, more regular in outline, and make up a larger proportion of the rock, which closely resembles the Portland oölite of England. The Arkansas stone, as quarried in one locality—Batesville—is harder and more crystalline than the Bedford stone. It is harder to work than the Bedford stone, but will take a smoother finish, and is sometimes used for ornamental purposes.

The Dolomites of Chicago.—The native rock in and near Chicago is chiefly limestone, which chemical analyses and microscopical examination show to be dolomite of more than average purity. It occurs in the Niagara group of Upper Silurian age, as evidenced by the fossil contents. The bed varies in thickness, well-borings in the city showing about 200 ft., but some of the quarry openings showing a thickness much greater. In the city and over the surrounding area the rockis in most places covered by a bed of glacial drift material, varying from a few inches to many feet in thickness.

The dolomite outcrops at four places in the city: 1. At Stony Island—Stony Island Avenue and Ninety-third Street. 2. At Bridgeport—Halsted and Twenty-seventh Streets. 3. At Eighteenth and Lincoln Streets. 4. At Grand Avenue and West Ohio Street. There are quarries on all these outcrops, two on the first, two on the fourth, and one on each of the others. The quarries at Stony Island have been abandoned for several years, but the others are all in operation. There is also an extensive quarry at Hawthorne, on the city line at the west side of the city, and numerous small quarries at Blue Island, just south of the city limits. There are still more extensive quarries southwest of the city, at Lemont, Lockport, and Joliet, along the line of the Drainage Canal. The rock quarried at these latter places differs in texture from that at Chicago, but is a dolomite of the same geologic age. Other dolomites, differing locally in character and in part in geologic age, but all of them important from an economic standpoint, are quarried extensively through the north central Mississippi Valley, in Illinois, Indiana, Ohio, Wisconsin, Minnesota, Iowa, Missouri and Arkansas.

Description.—The dolomite as it occurs in Chicago is finely but imperfectly crystalline, light to dark-gray in color, and contains many seams and joints. Some layers are much more seamed and fractured than others, the seams in places filled with fine-grained clayey material, giving the rock the appearance of being much more impure than it really is. In many places small, irregular, geodetic cavities abound, some lined with crystals, some filled with bituminous matter, others filled with clay. On weathered exposures it is in some places stained yellowish-brown by the oxidation of inclosed pyrite; in other places it is covered with black patches of bituminous material which has exuded under the influence of the sun's heat. The strata are in some places nearly horizontal, in others much folded. Thus at Stony Island the strata on the north side of the island dip 35° to 45° in a northwesterly direction, while on the south side of the island they

dip 30° to 40° in a southeasterly direction. In the Hawthorne quarry they dip 20° to 30° in different directions in different parts of the quarries. The separate strata vary in thickness from a few inches to 5 ft. or more. The stone at Blue Island is in many ways quite different from that in the city. It is not cracked and fissured like the dolomites in the city, but is much softer and less durable. On a fresh surface it has a dark blue-gray color, which changes to yellow or buff on exposure. It has a dull, earthy luster, revealing no crystallinity to the naked eye, but under the microscope it appears finely crystalline. The strata are horizontal, and vary from 2 in. to 18 or 20 in. in thickness.

The prevailing fossils in most of the quarries are corals, which are so abundant in places as to suggest at once the origin of the rock. However, no fossil corals have been observed at Blue Island, and the rock there is more than half composed of non-calcareous sedimentary material, and is essentially different from the other dolomites.

The rock in the city quarries is a comparatively pure dolomite; much purer, in fact, than its color and general appearance would lead one to think. Normal dolomite consists of the double carbonate of lime and magnesia in equal proportions by volume, or by weight of 54.35% carbonate of lime to 45.65% carbonate of magnesia.

The following analyses (with the exception of Nos. 5 and 6) were made by the writer in the chemical laboratory at the University of Chicago, and will show the chemical character of the rock:

ANALYSES OF CHICAGO DOLOMITES.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.
Lime carbonate ($CaCO_3$)	52.75	53.70	52.07	54.99	54.48	31.60	23.38
Magnesia carbonate ($MgCO_3$)	44.28	42.34	42.18	44.04	43.93	22.24	19.40
Iron oxide (Fe_2O_3) and alumina (Al_2O_3)	0.55	1.04	1.78	0.58	0.64	1.20	2.04
Insoluble residue, mostly silica (SiO_2)	0.60	1.28	4.00	0.87	0.14	43.72	54.34
Alkali, water, etc.	1.82	1.64	.....	.....	0.81	1.24	0.84
Total	100.00	100.00	100.03	100.48	100.00	100.00	100.00

Excepting Nos. 6 and 7, all the analyses are of samples from the quarries in the city. It will be noticed that in only one instance do the impurities exceed 5%. While the iron was determined as iron oxide, it consists mostly of the sulphide in the form of pyrite. The excess of insoluble material in No. 3 is accounted for by the fact that it was a selected sample from an exceptionally lumpy, impure-looking stratum. It is from the same quarry as No. 2. Nos. 6 and 7 are from Blue Island, and the analyses of their insoluble residue gives silica 75.35%, alumina with a little iron oxide 15.70%, alkali 8.55%, and magnesia oxide 1.03%, a composition of an average granite.

Mineral Composition.—The body of the rock is made up of finely crystallized dolomite, calcite crystals appearing in some of the cavities. Bitumen occurs in minute particles diffused through the rock, and in places, on faces of the quarry exposed to the sun, it is often drawn to the surface in considerable quantities, filling cavities, and even running down the face of the rock in a thick, tarry stream. Pyrite is diffused through the rock in minute quantities and in some places forms an incrustation in the seams. It is most abundant in one of the

Stony Island quarries, where it occurs 2 or 3 in. thick in fissures. Small quantities of chalcopyrite also occur. Microscopic examination of the stone from Blue Island, shows it to consist of very finely crystallized dolomite, with small fragments of quartz, feldspar and mica, such detritus as would come from the erosion of granite. Pyrite, sphalerite (zinc sulphide), and millerite (nickel sulphide) occur in geodic cavities.

Uses.—At the present time the stone taken from the city quarries is nearly all used for burning into lime or as broken stone in street work and in breakwaters along the lake front. A small proportion is used as a flux in the iron furnaces and a small quantity for building foundations. The objections to its use in superstructures are its much jointed and fractured condition, and the pyrite and bitumen in it, which discolor it when exposed to the weather. The major part is used as crushed stone in the streets of Chicago, for which use it is peculiarly well adapted, the numerous incipient cracks and fissures and its softness rendering it easily crushed, and its location in various parts of the city reducing the transportation to a minimum.

Next in importance is its use for making lime. The ease with which it can be quarried and reduced to proper dimensions for the kiln adds to its value in this respect. The lime made from it seems to give good satisfaction to builders and contractors for masonry and plastering. While it does not give quite as large a bulk on slaking as the purely calcareous lime, it slakes to a white, impalpable powder, which makes a fine, smooth mortar. It has hydraulic properties, which add to its value. Workmen testify that in taking down or cutting through old walls, the stone or brick will frequently break before parting at the seam. While the use of the lime is constantly increasing, the price is decreasing, which is no doubt due in part to increased facilities for quarrying and burning it, in part to the lower price of labor, and in part to greater competition. The price in 1894 was 43c. per barrel; in 1893, 45c.; in 1892, 55c.; in 1890, 55c.; in 1870, 65@75c.; and in 1860, 80@90c.

One of the larger quarries in the city produced during 1894 a total of 200,000 barrels of lime; in 1893, 204,000 barrels; and in 1892, 370,000 barrels. It also produced 50,000 tons of crushed stone as compared with 38,000 tons in 1893, and 80,000 tons in 1892. The figures from the other quarries are not accessible, but this probably represents about one-third of the production in the city. One of the oldest quarries in the city was opened in 1859, and now has an opening 170 ft. deep, covering an area of 8 acres, which represents 59,000,000 cu. ft., or nearly 5,000,000 tons of limestone taken from this one quarry. This is probably the largest opening in the city, but a quarry just outside the city limits has a larger opening by about one-third. The stone at Blue Island was at one time burned for cement, but is now used only for building foundations.

Great quantities of dolomite are quarried at Lemont, Lockport, and Joliet, and shipped to Chicago for use as building stone. The majority of the business blocks, flats, and private houses that are built at present, if not constructed entirely of stone, have at least stone trimmings, and most of them have stone fronts. The Lemont and Joliet dolomite is in demand for such use.

Connecticut Brownstone.

The brownstone quarries along the Connecticut River—notably those near Portland and Cromwell in the State of Connecticut—are the oldest industries of the kind in the United States. At the places named regular and systematic quarry operations have been carried on for over a century, and for the greater part of that time a large quantity of their product has been yearly placed in the larger cities of the country. It is from the working of old established industries like this that valuable statistics can be gathered and valuable comparisons made as to the effects of the application of improved machinery and business methods.

Triassic brownstone, the geological term, stands for several varieties of stone found in limited areas in several States of the Union. But no stone yet discovered equals in quality and value that from the deposits occurring at Portland and Cromwell in Middlesex County, Connecticut. The firm, evenly laminated matrix and uniform color of the Connecticut stone, its entire freedom from clay, marl or gravel which weather out on exposure or fracture out in working, make it an article of commerce so desirable that frequently the resources of the quarries are taxed to supply it in quantity and quality wanted.

The physical characteristics of the stone, distinguishing it from all others, consist of its uniform color, a rich permanent brown, tinted slightly reddish, gray or bluish, according to various strata, its fine even rift or reed, its easy working qualities adapted to the finest carving, and its susceptibility of taking a perfectly smooth, even surface by rubbing or dressing down. Chemically resolved, it is found to be composed of: Silica, 70.11%; alumina, 13.49%; iron oxide, 4.85%; manganese, 0.35%; lime, 2.39%; magnesia, 1.44%; soda, potash, etc., 7.37%—total, 100%.

The silica base is a crystalline quartz of granular formation, firmly held or cemented through centuries of chemical changes. The iron oxide accounts principally for the coloring. When first quarried the stone contains a certain amount of moisture—"quarry water" so called—which evaporates on exposure until a well-seasoned 12 in. cube, perfectly dry, will weigh 150 lbs. 12 ozs., showing a specific gravity of 2.35; completely immersed in water for three months the stone will increase its weight to 154 lbs. 12 ozs., an increase of 4 lbs. net for 150 lbs. weight of stone or a ratio of absorption of 1 : 40. Tests recently made by the Ordnance Department, United States Army, at the Watertown Arsenal, show an average resistance of 10,602.8 lbs. per sq. in. Other tests made by Colt's Patent Fire Arms Manufacturing Company of Hartford, Conn., give 10,928 and 10,322 lbs. per sq. in. for the grades No. 1 and No. 2, or building stone.

The quarries are opened to a depth of 200 ft., where the stone lies evenly bedded, with a slight pitch, say a drop of 1 ft. in 20. Natural joints exist which are taken advantage of, but the new machinery used admits of working more evenly, and little attention is now paid to following the natural joints. Channeling machines, steam drills, and the Knox system of blasting are employed. Average blocks run from 2 to 5 ft. in thickness, although blocks measuring 128 ft. long, 20 ft. wide and 11 ft. thick have been loosened clear at one blast. Splitting these immense blocks is accomplished by plugs, feathers and wedges. The hoisting, formerly done by oxen up an incline, is now entirely done by

derricks and cranes, blocks weighing 20 tons or over being brought to the surface in less than two minutes. The yards are very extensive; shifting, hauling, etc., was formerly a slow and expensive proceeding. A complete railroad system with locomotives and cars and locomotive cranes now accomplishes in minutes what used to take hours. The stone is transported to market by a fleet of sailing vessels owned by the quarries, some 30 in number; the water front and dock facilities on the lands of the quarry companies affording easy transportation, besides which, the grounds are connected with both the New York, New Haven & Hartford and the New York & New England railroads.

Connecticut brownstone, although used to some extent for monumental purposes, is primarily a high-grade building material, being used in large quantities in cities, not only where stone fronts are a particular feature, but in connection with brick and other materials, with which it combines very effectively. It has been taken to all the large cities of the country, even as far as San Francisco, by way of Cape Horn. In that city the finest house on the Pacific coast stands, a mark of appreciation of this stone. In New York City the finest mansions of the wealthier classes are of Connecticut brownstone. The stone has been used so exclusively in New York that it has given a distinctive style to the architecture of entire sections of the city.

When writing of the uses of Connecticut brownstone we should not omit to refer to two points in connection therewith in which the material has been very greatly misused. In active building days everything was sacrificed to the pressure of time, and stone taken fresh from the quarries, with no interval whatever for seasoning, was quickly split up and put into buildings in weather and season when ordinarily building operations are suspended. The quarries usually stop work on the approach of freezing weather, for the reason that a temperature of 22° F. or lower when the blocks are "green" and filled with "quarry sap" is sufficient to burst the stone. There have been many seasons in the past, however, when, under the pressure of time contracts, builders and the trade have insisted that stone be taken out rather than buildings delayed, and all responsibility resting with these parties they have taken all chances against the season and sound advice. This abuse occurred at a time before the quarries were as well equipped as they are at present. Their facilities now permit them to carry a large stock of well-seasoned stone ahead at all times, but some bad effects of that by-gone period are visible now in stone which has not weathered well from that cause alone. Sir Christopher Wren, the great architect of St. Paul's in London, understood this well when he stipulated that "no stone should be used in the construction of that edifice which had been quarried more recently than three years."

The second abuse is even worse than the first. The stone is at a great disadvantage if not set in the building on its natural bed. It has been almost the universal custom of the trade in the past to split the stone with the grain or reed; it split evenly and cleanly, and saved the cost of sawing, saved labor and expense; but here again is seen mechanical progress. The modern diamond-saw has obviated such methods, and whereas the cost of laying the stone "on bed" is now slightly in excess, it is no such item as in the days of hand labor, and will well repay the small additional investment. No one better than the stone-cutters

themselves realizes this, and knows its great advantages. They are ready to adopt the newer practice, but will estimate in competition, the cheapest way every time, unless specifications particularize "the natural bed." No case of scaling or flaking need occur if these simple and natural precautions are observed, and even those who build "to sell" are beginning to come round to this position. Architects, when using Connecticut brownstone, should always specify "The stone to be set in the building on its natural bed." It will then be utilized as nature placed it. It is only in this country that such a specification seems necessary; in England and on the Continent no stone is ever set otherwise.

The historical development of the quarries goes back to 1665, when the value of the stone was appreciated, as is shown by the Middletown town records as follows:

"Sep. 4th, 1665. At a town meeting it was voated that whosoever shall dig or raise stones at ye rocks on the east side of the river for any without the town, the said digger shall be none but an inhabitant of Middletown, and shall be responsible to ye towne twelve pence per tunn, for every tunn of stones that he or they shall dig for any person whosoever without the town; this money to be paid in wheat and pease to ye townsmen or their assigns, for ye use of ye towne, within six months after the transportation of the said stones."

In 1690 six acres now in possession of the Middlesex Quarry Company were sold by the town to James Stanliff. Nearly a century later, 1788, this property passed into the hands of Shaler & Hall, by whom the real work of quarrying was begun. In 1791 the same firm bought the ground of the lower quarry, now known as the Shaler & Hall Company's quarry, with a view to more extended operations in the future. In the meantime other parties were not idle, but purchased the ground between the quarries now known as the Middlesex Quarry Company's, and the Shaler & Hall Quarry Company's. Hurlburt & Roberts began work on this space in 1783, and in 1814 Erastus and Silas Brainerd bought it and carried on the business successfully until Silas Brainerd died, when the firm of Brainerd & Co. was formed. In 1819 another quarry was opened, contiguous to the six acres bought by Shaler & Hall in 1788, under the name of the Patten & Russell Quarry, until 1841, when it was united with the original Shaler & Hall property of six acres, and the firms were incorporated under the name of the Middlesex Quarry Company. This, in brief, is their early history, and shows the commencement of active work, when they really deserved the name of quarries. Other lands have since been acquired from time to time as the increase of business demanded them, the entire area at the present time being not less than 1000 acres, operated by the following companies: The Middlesex Quarry Company, incorporated 1841; the Brainerd Quarry Company, incorporated 1879 as the successors of E. & S. Brainerd and Brainerd & Co., who had previously existed as firms since 1812; the Shaler & Hall Quarry Company established as heretofore stated, and incorporated in 1844, located at Portland, Conn.; the New England Brownstone Company and the Connecticut Freestone Company, incorporated in 1886 and 1892 respectively, located at Cromwell, Conn., all lying with an area of three miles.

The five companies named above employ during the year a force varying from 1100 to 1200 men. The quarrying season lasts 8 months, the average rate of wages at present being $2 per day. In 1880 it was $1.55; in 1870, $2.50; in 1860, $1.10; in 1850, $1. Going back as far as 1844 we find the wages to have

been at that time 75c. per day. Wages are arranged now on a summer and winter scale, no quarrying being done during the winter months, that time being devoted to stripping and general cleaning up, preparatory to the active quarry season beginning with the early spring. The prices of stone at the quarries have ranged from 50c. per cu. ft. for first quality in 1844, as follows:

1846	$0.60	1864	$0.80	1869-74	$1.25	1876	$1.03
1849	.60	1865	1.00	1874	1.26	1891	.95
1863	.65	1866-69	1.05	1875	1.08	1893	.95

The annual production of first quality stone will vary somewhat between 850,000 and 1,000,000 cu. ft. About twice that quantity of coarser grades is sold annually as bridge stone for piers, foundations, abutments, walls, etc. The various items of expenditure at the quarry are, first and most important, labor; second, freights and transportation; third, coal; fourth, general supplies, exclusive of betterments; fifth, salaries; sixth, taxes; seventh, insurance.

Quarry lands in the Connecticut brownstone district are not generally in the market. A value is placed upon them ranging from $30,000 to $40,000 per acre in favorite localities, in which tests show good quality of stone; but no land is seeking a market even at that price.

MARBLE.

By T. C. HOPKINS.

The marble industry, like all other branches of trade, suffered somewhat from the general business depression, but probably no more than any other branch of the stone trade. Many of the dealers report the general condition of the marble trade better now than at the close of last year and the prospects good for renewed activity during the coming year. Owing to the light demand but few new quarries were opened. Reports have come to us of new discoveries and partial developments of fine marbles in Colorado, where the presence of marble has long been known and where the stone has been quarried to some extent for local use; but more extended researches now show the presence of finer grades than were heretofore known.

The following table shows the general condition of the trade. It includes the values of the production of all the larger companies and many of the smaller ones, and the figures for the two years, while not entirely complete, are as nearly so as they can well be made, since it is impossible to secure returns having any approach to accuracy from the smaller quarries. The table for the two years is as follows:

MARBLE PRODUCTION IN THE UNITED STATES.

States.	1893.			1894.		
	No. Quarries.	Cubic Feet.	Value.	No. Quarries.	Cubic Feet.	Value.
California	1	23,166	$43,912	1	26,580	$50,830
Georgia	1	1,500	3,000	1	47,000	141,000
Illinois	1	25,000	142,000	1	25,400	144,000
Indiana	13	2,446,199	527,211	13	2,716,090	576,243
Maryland	1	30,990	21,852	1	39,777	23,475
New York	2	37,000	39,500	2	39,231	42,876
Pennsylvania	1	11,000	22,000	1	12,000	24,000
Tennessee	3	54,157	51,150	3	47,197	48,577
Vermont	3	3,010,669	1,237,133	3	2,728,491	1,126,279
Total	25	5,639,681	$2,087,758	26	5,681,766	$2,177,280

Probably the increase in totals from the smaller quarries would be not far from $200,000 in each year. It is noteworthy that the marbles that have suffered the greatest depression are those that are used for monumental purposes. Those used largely for building or decorative purposes have suffered little decrease. The New York and Maryland marbles are nearly all used for building purposes, both in outside walls and interior decoration. The California and Tennessee marbles are largely used for interior decoration, the former reporting 70% of their output taken for such use, and the latter 80%. The Georgia marbles are finding increased demand for decorative purposes, the present estimate being that they furnish from 10% to 20% of the total so employed. The Vermont producers estimate about 8% of their product used for interior decoration, the bulk of their output being used for monumental purposes. The product from Vermont still continues largely in excess of that of all the other States combined. The figures for the production in Pennsylvania are not available.

The value of the marble exported from the United States for the year equals $98,956, of which about $8,000 was from New York and $60,000 from Vermont. The value of the marble and manufactures of marble imported into the United States for the year was $787,657, as compared with $1,062,843 for 1893, a decrease of 34.9%, or more than three times as great as the decrease in the domestic production.

Chicago is a large consumer of marble, taking more than any other city in the country. It is estimated that the receipts of marble in that city in 1894 amounted to about 11.5% of the domestic product. All of this was sent from four States, and includes 13.4% of the Vermont product, 9% of the Georgia, 16 %of the New York and 15% of the Tennessee product.

Marble in Georgia.

According to a report made by S. W. McCallie, Assistant State Geologist, all the marble in Georgia so far discovered is in a narrow belt extending about 60 miles through the counties of Fannin, Gilmer, Pickens and Cherokee, in the northern part of the State. This belt appears to lie on the border between the well-known Paleozoic group and the broad belt of crystalline rocks. The district in which marble is found is generally hilly and in some places even mountainous, some of the ridges reaching to over 4000 ft. above sea level. The numerous valleys intersecting this region are generally narrow, but very fertile, while the ridges separating the depressions are generally unproductive, except where underlaid by black soil or marble. Either of these weathers into a rich soil heavily timbered with oak, chestnut, poplar, hickory or other species of trees. The trend of the valleys and ridges is generally northeast and southwest, corresponding in direction to the strike of the strata, but there are local variations which are most marked in the neighborhood of the great mountain masses found in Gilmer and Pickens Counties.

The working of this narrow belt to a commercial extent is comparatively recent, although some early attempts were made, as described below. Among the principal workings now in existence are the Southern Marble Quarries, which were opened in 1885 by Miles & Horne, contractors for the State Capitol of

Georgia; the marble for the stairs and tilings used in this building was taken from the Southern Quarries. In 1885 also George B. Sickles & Co. began work near Tate, and in the following year the Piedmont and the Blue Ridge Marble Companies were organized. These do not comprise by any means all the quarries in operation, but include the principal works. Most of the marble quarried in this region now finds its way to market over the Marietta & North Georgia Railroad, which is connected by spur tracks with most of the larger quarries and works. The quality of the Georgia marble is considered excellent, both for building and for monumental work, as the finer stone takes a very good polish and can be closely and evenly worked. While its market is, of course, restricted to a certain extent by the cost of railroad freight, it has under special circumstances come in competition with the marble of the Northeast. At least one contract for a large building in New York has been supplied from this district, while shipments as far as Chicago are not uncommon.

Mr. McCallie, in his report, gives some interesting historical notes. The outcroppings of the marble ledges of Pickens County attracted attention at a very early date. The Cherokee Indians, who inhabited this section before its exploration and settlement by white men, worked the marble into bowls and other forms, and specimens of their work are preserved to the present day. The first quarry opened was in 1840, when Fritz T. Simmons began work on a small scale in the Longswamp Valley, near Tate. The stone which he used is said to have been obtained chiefly from outcrops and boulders found on the hillsides, and was naturally not of the best quality; the impure and laminated varieties were frequently selected on account of the comparative ease with which they were worked. For two or three years all the work was done by hand, but Simmons then erected a mill with one gang of saws on the east branch of Longswamp Creek, near the point where Marble Hill post office is now located. This was the first mill put up in Georgia for sawing marble, and appears to have been a primitive affair, although the general methods were the same as those now used. Two or three years afterward another mill was built on the west branch of Longswamp, near Jasper, and this was run for several years. The stone taken out in these quarries was used only for tombstones, and specimens of it may be found in nearly all the graveyards of northern Georgia. In 1850 the firm of Tate, Adkinson & Co. opened a quarry near the point where the Georgia Marble Works now stand, and erected two mills of considerable capacity. These works continued in operation for several years, when work was finally suspended. In 1854 another quarry was opened near Jasper, where considerable work was done, and stone was taken out at this point until the commencement of the war. After the war work was resumed, but the operations continued for about two years only, when the quarry was abandoned and nothing further was done toward the development of the Georgia marble until about 1885, as noted above.

Tests made of Georgia marble show a resistance to crushing equal, for Kenesaw stone, to from 12,200 to 13,700 lbs.; for Southern Quarry marble from 13,200 to 13,700 lbs.; for Georgia Quarry from 14,700 to 16,700 lbs. Chemical analyses of the white fine-grained marble quarried near Jasper showed 52.75% calcium oxide; 19.37% magnesium oxide; 0.35% ferric oxide and alumina; loss on ignition 46.58%. The coarse-grained black and white mottled marble from the

Creole Quarry of the Georgia Company gave 55% calcium oxide; 1.12% magnesium oxide; 0.15% ferric oxide and alumina; 0.35% insoluble siliceous matter; loss on ignition 44.16%. A fine-grained bluish-gray marble from Gilmer County gave 31.61% calcium oxide; 21.016% magnesium oxide; 0.78% ferric oxide and alumina; 1.01% insoluble siliceous matter; loss on ignition, 46.49%. A fine-grained light gray marble from Cherokee County showed 24.07% calcium oxide; 17.24% magnesium oxide; 0.43% ferric oxide and alumina; 21.76% siliceous matter; loss on ignition 37.08%.

It may be added that the use of Georgia marble is gradually extending, as the excellence of the stone for building purposes becomes more generally known.

Onyx.

As yet no extensive deposits of so-called onyx have been found in the United States; at least none having the necessary qualities to give it a place in the market. The only exception is a white onyx with grayish veining, which was found in California; the quarry seems to have been quite productive for a number of years but has been out of the market for the last two or three years for some reason, possibly because the bed is exhausted.

The finest onyx ever discovered in the United States was found about three years ago near Prescott in Arizona. This stone was of a greenish pink with brown veining; a small quantity of it came to the Eastern market, but the quarry never produced more than about 1000 ft. It is not seen in the market, probably because the price of quarrying and the freight rates to the Eastern markets are so high that it cannot compete with the onyx shipped from Mexico, which has the advantage of water transportation; moreover the colors are less brilliant, and it is not equal in beauty to the better grades of onyx from Mexico, although it is the handsomest ever found in the United States.

At the Chicago Exposition samples of onyx were exhibited which were of great beauty and which came from California, but this stone has never made its appearance upon the market.

Deposits of onyx are quite numerous throughout Colorado and Utah, and there is also a deposit in Virginia. All these deposits contain a rather coarse onyx, partly honeycombed and of a muddy appearance, ranging from a yellow to a dark brown, almost black color. Although not of the best quality these would look very handsome and answer well for some purposes.

Samples of the same description of onyx from Utah have a clear deep yellow color, almost a gold color. These are the handsomest of the class of onyx just referred to. It is stated that the ledge of this yellow onyx is quite extensive and that large blocks could be obtained. While a good stone it would not be handsome enough, according to experts, to find a market for the finer kinds of work, and would not compete with the Mexican onyx except for wainscoting and similar work, for which it would answer well.

SULPHUR.

THE subject of sulphur was so fully treated in THE MINERAL INDUSTRY, Vol. II., that very little is to be added this year beyond the statistics. No new discoveries of commercial importance can be mentioned during the year, although some reference is made below to a new deposit lately explored but not yet brought into the market. As heretofore, Italy continues the most important producer, especially as far as the United States is concerned, nearly all the brimstone brought to this country coming from Sicily. The Japanese mines have continued to be worked and some improvements have been introduced into the methods of mining and transportation, especially at the Atosanobori mines on the Island of Hokkaido, in which are found also the Iwaonobori, the Ichibishinai and the Osorezan mines. The greater part of the Japanese production is controlled by the Mitsio Company, which has built a railroad and docks to facilitate the shipment of its output; these works were extended considerably last year.

No new developments are to be reported in the United States during the year. The following table shows the production, imports and consumption of sulphur in the United States for the five years from 1890 to 1894 inclusive.

SULPHUR PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION IN THE UNITED STATES.

Year.	Production.			Imports.								Consumption.	
	Sulphur.			Crude.		Flowers of Sulphur.		Refined.		Total.			
	Long Tons.	Value.	Value Per Ton.	Long Tons.	Value.	Long Tons.	Value	Long Tons.	Value	Long Tons.	Value.	Long Tons.	Value.
1890..	.....	.....	.....	131,096	$2,147,481	12.06	$1,718	103.00	$3,060	131,211	$2,152,259	131,211	$2,152,259
1891..	1,071	$39,600	$37.00	116,971	2,675,192	206.00	6,782	10.00	1,997	117,187	2,683,971	118,208	2,722,026
1892..	1,630	54,750	33.00	100,938	2,189,481	158.00	5,439	26.00	4,106	101,122	2,199,026	102,752	2,253,773
1893..	1,200	26,880	22.50	107,601	1,903,191	240.96	5,746	41.73	1,017	107,885	1,909,954	109,020	1,935,474
1894..	441	7,410	17.00	124,467	1,734,643	165.00	4,145	41.00	1,207	124,673	1,739,995	125,114	1,747,405

As Italy is the most important producer of this mineral from a commercial point of view, we give below tables showing the output of that country for the years beginning with 1880, and also the exports of Sicilian sulphur to various countries for the years beginning with 1889.

PRODUCTION AND EXPORT OF SULPHUR FROM ITALY. (*a*) (IN METRIC TONS; $1=5 LIRES.)

Year.	Production of Sicily.		Total for Italy, including Sicily.			
			Production.		Export.	Average Value of 1 ton at Shipping Port.
1880.....	312,921	$6,280,506	359,633	$7,293,118	287,149	$20.07
1881.....	323,151	7,450,178	373,160	8,381,593	289,365	23.06
1882.....	394,087	8,275,827	445,918	9 328,508	273,347	21.00
1883.....	391,689	7,442,093	446,508	8,478,640	288,381	19.00
1884.....	367,712	6,545,273	411,037	7,304,406	277,210	17.80
1885.....	377,194	6,261,420	425,547	6,992,826	289,257	16.60
1886.....	326,657	4,978,252	374,343	5,592,456	300,881	15.24
1887.....	300,757	4,181,148	342,215	4,738,839	279,628	13.90
1888.....	322,042	4,302,481	376,538	5,002,602	323,790	13.29
1889.....	327,672	4,348,838	371,494	4,930,575	331,902	13.27
1890.....	328,024	5,092,207	369,239	5,653,058	328,708	15.31
1891.....	347,568	8,035,077	395,528	8,905,091	269,376	22.51
1892.....	374,359	7,125,249	418,535	7,844,333	291,081	19.03
1893	374,840	5,423,935	417,671	5,923,335	310,867	14.51
1894.....	373,000	.....	415,000	.....	298,400	.....

(*a*) From *Notizie e Studi sulle Conditioni dell' Industria dello Zolfo*, Rome, 1894.

EXPORT OF SULPHUR FROM ITALY TO VARIOUS COUNTRIES. (*b*) (IN METRIC TONS.)

Year.	Austria-Hungary.	Belgium	France	Germany	England.	Holland.	Portugal.	Sweden and Norway.	Turkey.	Spain	Greece	United States and Canada	Russia.	Australia	Other Countries.	Total.
1889	12,690	8,667	68,824	20,652	39,224	2,584	8,559	4,059	2,717	13,853	10,501	117,423	17,157	.....	4,991	331,901
1890	16.593	7,420	73,596	15,611	28,701	1,596	18,929	5,312	8,162	6,456	15,206	111,198	14,387	104	5,437	328,708
1891	15,490	5,241	58,262	12,067	26.681	1,837	7,309	1,296	2,996	7,726	11,326	101,578	12,752	20	4,795	269,376
1892	13,499	5,582	77,424	18,668	24,739	2,465	11,240	4,295	3,068	9,437	12,887	89,557	11,186	2,282	4,751	291,080
1893	13,807	3,957	91,722	17,531	25,286	3,070	12,615	3,343	4,931	6,762	11,450	89,044	19,174	1,726	6.449	310,867
1894	10,427	5,120	51,648	14,912	20,108	2,145	7,865	7,155	11,664	3,125	4,640	95,956	16,308	.....	3,063	254,136

(*b*) From *Notizie e Studi sulle Conditioni dell' Industria dello Zolfo*, Rome, 1894.

According to a recent article by Mr. Louis Pelatan,* among the sources from which a large supply of sulphur can be obtained is the group of the New Hebrides near New Caledonia, forming a true dependency of that island, both from a geographical and a commercial point of view. The existence of sulphur deposits on some of these islands has been known for several years, but recent explorations have been made of those on the island of Tanna in the southern part of the group and also on the island of Vanna-Lava in Bank's group.

The island of Tanna is situated between 19° and 20° south latitude and about 270 miles northeast of New Caledonia. It is one of the smallest islands of the group, having an area of 60,000 hectares. The sulphur deposits are found near the southeast coast, between a deep inlet which has been named Port Resolution and an open bay called Sulphur Bay. The deposits are closely related to an active volcano, which is a conical mountain having a crater of elliptical form situated on the south side obliquely to the base of the mountain. The longer axis of the ellipse is about 900 meters and the shorter 600 meters. The south side rises about 200 meters above the northern edge, the latter being about 400 meters above sea level. The mountain is almost always in activity, and from time to time there are explosions, accompanied frequently by discharges of lava, while occasionally large rocks are thrown into the air with much force. The sides of the mountain are chiefly formed of lava and scoria and are also

* *Le Genie Civil.*

remarkable for the vitreous matters which are found in abundance. Although the mountain stands almost alone in the middle of a plain, which is entirely of lava and scoriaceous formation, it nevertheless appears to be connected at the northwest with a mass of hills, also of volcanic origin, which occupies nearly all the country between Port Resolution and Sulphur Bay. Toward the east a hilly or mountainous chain of some importance extends from the volcano. At the foot of this chain is a fresh-water lake of considerable size into which flows a small river. According to the natives this lake is never dry ; apparently it owes its existence to the volcano, since the lava from the mountain has cut off the flow of the river and has dammed up the water which originally found its way to the sea.

Two deposits of sulphur have been examined and are known, the first being on the northern slope of the volcano looking toward Sulphur Bay, the second on the opposite slope, that is, on the south side of the mountain.

The first, or northern deposit, is found in a sort of ravine which seems to mark the existence of an ancient trench or seam in the mountain, which was perhaps open at one time and discharged lava, but has since been filled up by sulphur and other volcanic matter. The outcrops of sulphur begin to be visible at a point about 60 meters above the level of the sea and extend to a point 260 meters above. They are found over a width of about 400 meters and, as far as examined, the thickness is from 8 to 10 meters. The sulphur-bearing rocks rest on a bed of reddish lava which is entirely distinct from the surface covering of black scoria and cinders. Beyond the limits named, the sulphur extends through several localities in the neighborhood in considerable quantity. After leaving the upper end of the region of outcrops and ascending to a height of 300 meters above the sea, a bare rocky plateau is found, which extends to the lower edge of the crater. On this plateau additional outcrops are found, less important than those below, but apparently an extension of them ; these outcrops are found over a space about 100 meters in width.

This southern deposit is found on the slope of the volcano at the head of the valley which extends from Sulphur Bay to Port Resolution and at the height of about 240 meters above the sea level. This deposit in form could be compared to a prism with a triangular base, standing upon a horizontal bed of lava and having only one of its three faces uncovered. This enormous prism is at least 40 meters in height and its base would form an isosceles triangle with the two longer sides of 200 meters each and the shorter side 100 meters.

In these two deposits the minerals show a great deal of similarity, and have evidently the same origin. In the northern deposit samples have been taken at different points of the outcrops, the sulphur being mixed with scoriaceous debris and cinders. The samples average, as assayed by distillation, care being taken to obtain a true average, 47% sulphur.

The samples from the southern deposit had a different appearance than those of the north, the scoriaceous gangue being less broken up and mixed with the mineral. Assayed in the same way as the other, the average result showed 58% sulphur. The average yield of the sulphur mineral taken from the Sicilian mines seldom exceeds 35% sulphur. In both the Tanna deposits the minerals are easily broken up in consequence of their great purity.

The treatment of this mineral at Tanna ought to be very easy. The mineral could be first broken up and sorted into large and small, and the larger lumps could be treated by what is known in Sicily as the "Calcarone" process which, with care, generally extracts about 50% of the sulphur contents. Considering the nature of the gangue and the ease with which it can be separated, it would seem possible that the raw sulphur might be obtained in a state so pure that it will hardly be necessary to refine it. The small or finely broken mineral which could not be treated by the Calcarone process could either be pressed into briquettes for that process, or be treated by heat, producing a raw sulphur less pure but very easily refined.

The island furnishes abundance of wood for use in treating the sulphur. The slopes of the volcano are covered with wood and the valleys are also heavily wooded, while the growth is very rapid, so that the supply of fuel would seem to be assured for a long time to come. Each of the sulphur deposits could be brought into communication with a landing, the northern deposit at Sulphur Bay and the southern deposit at Port Resolution. In either case from 5 kilos to 8 kilos of road or railroad would be needed, but in both a good line can be found with a gradual slope toward the sea.

Labor could be found without difficulty. Like nearly all the natives of the New Hebrides, those of Tanna are not unwilling to work, and with proper treatment their services could be secured at a moderate rate.

The market for these deposits will hardly be found in Europe since the long voyage and the rates of freight would prevent their coming into competition with Sicilian sulphur. In New Zealand, however, in Australia, China and on the west coast of the American continent outlets, could doubtless be found for all the sulphur that can be produced. Australia already imports sulphur from Europe for its chemical industries. In New Zealand there is an important and growing industry in the conversion of the phosphate of lime found in the island into superphosphate, and there is a considerable demand for sulphur for the manufacture of sulphuric acid. In California and in South America, especially in Chile, there is a great demand for the mineral which could be supplied as easily or more easily from Tanna than from any other point. There is no doubt that a sufficient market can be found if the working of the deposits is undertaken.

Several of the small islands in the West India group contain large deposits of sulphur, but thus far they have not turned out any large commercial product.

The great deposit in Louisiana, probably the most important in the world, has not yet become a producer, though an experiment is being made there with a process which contemplates melting the sulphur in place with hot water and pumping it up through a pipe. No commercial results are yet reported. The Texas deposits are known to be large, but their distance from market and even from a railroad has thus far prevented their exploitation.

TIN.

So far as the production of tin in the United States is concerned there is little or nothing to be said. The several attempts to open and operate tin mines in this country, which have been referred to in previous volumes of The Mineral Industry, have all proved failures. At the Temescal mines, in California, nothing was done in 1894, nor was any serious attempt made at further explorations of the discoveries in Virginia and North Carolina. The affairs of the Harney Peak Tin Mining Company, in South Dakota, reached a crisis during the year through the action of some of the English stockholders, who began suit in the United States circuit court, alleging misrepresentations and fraud on the part of the managers and procured the appointment of a receiver for the company, Dr. A. R. Ledoux, of New York, being appointed by the court to that position. Under his management the affairs of the company are being adjusted, and it is probable that the true value of the property will be impartially ascertained and reported.

Although no contribution was made by the United States, the total production of the world continues to increase. The shipments from Australia did not increase in 1894, and those from Bolivia were small, but the output of tin from the mines in the Straits Settlements and the outlying districts of the Malay Peninsula continue to grow with the demand, and there has also been an increase in the Banka and Billiton mines of the Dutch East Indies.

The production of English tin is declining. The old mines of Cornwall, which have been worked for so many years, are no longer able to meet the competition of the East owing to the greater richness of the East Indian deposits, and to the cheapness of labor in those countries. An influence which was also very unfavorable to the Cornish mines, was found in the low prices of silver, which reduced the expenses of working the Eastern mines, as they are all situated in silver standard countries, where wages and all expenses are payable in the depreciated metal. In the latter part of the year a proposal was made to reorganize one or two of the leading Cornish companies and to adopt improved machinery and methods of working in place of the ancient system which used to prevail in that district. It is probable that this plan will be carried through,

and in that case Cornwall may once more become an active competitor in the market. At present most of the companies have been working without profit for two or three years. Their stock is at a very low ebb, and it is not unlikely that many of the mines will be abandoned unless some change is made in the condition of affairs.

Owing to the peculiar nature of tin ores, the manner in which they are usually found, and the labor conditions in the countries which furnish the chief part of the supply, little or no improvement in mining or metallurgical methods is to be looked for, and none can be reported during the year. In the Straits Settlements, and in the adjoining Penang and Perak districts, the business is falling more and more each year into the hands of the Chinese, who form an important element of the population and who have gradually replaced the native Malays, owing to their superior industry and business acuteness. Some interesting reports have been published during the year on these districts, notably on Perak, which is now perhaps the most important of all; but as we have said before, they have stated nothing new as to mining or metallurgy and it is not likely that much change will be effected in those countries.

The following tables give the production and consumption of tin for five years and the stocks on hand at the close of each year, showing what are technically called the "statistics" of the trade. The figures for the years prior to 1890 will be found in THE MINERAL INDUSTRY, Vols. I. and II. The figures are in tons of 2240 lbs.

STATISTICS OF TIN FOR THE WORLD. (*f*)

	1890.	1891.	1892.	1893.	1894.
PRODUCTION:					
English production	9,000	9,353	9,270	8,213	8,000
Straits' shipments to Europe and America	27,470	31,457	34,648	39,670	46,640
Australian shipments to Europe and America	6,415	5,991	5,972	5,579	5,824
Banca sales in Holland	5,317	5,350	6,300	5,244	5,626
Billiton sales in Java and Holland	5,232	5,753	5,560	5,462	4,735
Bolivian arrivals in England	1,664	1,559	2,819	2,909	3,482
Total	55,098	59,463	64,569	67,077	74,307
CONSUMPTION:					
Deliveries from London after deducting all shipments to America	16,126	17,667	14,122	18,663	18,050
Deliveries from Holland after deducting exports to London and America	8,155	8,246	8,719	7,853	8,207
English consumed at home	3,872	3,834	3,158	2,260	2,314
Exports of English, minus quantity shipped to America	4,567	4,990	5,648	6,554	5,686
American consumption of all sorts	16,000	15,457	18,750	19,000	16,650
Billiton sent to other ports than Holland	1,617	1,972	2,605	1,919	862
Straits direct to Continent, less re-exports to America and England	3,700	3,579	5,500	8,900	11,725
Bolivian delivered from Liverpool	1,622	1,658	2,656	2,704	3,323
Total	55,659	57,403	61,158	67,853	66,817
STOCKS, DEC. 31:					
Stock of foreign in London	2,524	2,155	2,776	4,392	8,985
Foreign landing in London	880	1,162	1,346	817	1,189
Straits afloat for London, including wire advices	1,205	2,225	2,170	3,470	3,778
Australian afloat for London, including wire advices	856	802	957	909	650
Banca on warrants in Holland	867	511	868	319	1,006
Billiton in Holland	277	357	326	640	1,632
Billiton afloat for Holland	1,396	1,912	1,240	1,600	1,129
Straits stock in Holland	.....	160	190	670	.....
	8,005	9,284	9,873	12,817	18,369
Estimated stock in America and quantity floating	2,925	3,228	5,492	2,730	3,820
	10,930	12,512	15,365	15,547	22,189
Trading Company's reserves of unsold Banca stock in Holland	2,787	3,140	3,480	4,200	5,770
Floating for Holland	303	.....	139	.....	.....

(*f*) From the Annual Metal Circular of W. T. Sargent & Sons.

The imports of tin into the United States for the five years, 1890–1894, inclusive, are given in the following table:

IMPORTS OF TIN INTO THE UNITED STATES.

Year.	Pounds.	Value.
1890	33,821,319	$6,869,645
1891	41,146,123	8,091,363
1892	46,821,958	9,415,889
1893	40,184,556	8,007,292
1894	39,268,628	5,944,065

A portion of these imports are from the producing countries directly, but the greater part comes from England and Holland, being reshipments of Straits or Banca metal. The reduction last year reflects the depression in business chiefly. The imports showed a reduction from 1891 and 1893; no comparison can be made with 1892, when the imports were swelled by exceptional causes. Since the close of 1894 the imports have shown a large gain.

The following table shows the exports of tinplates from the United Kingdom for the five years 1890–1894, inclusive:

EXPORTATIONS OF TINPLATES FROM UNITED KINGDOM, IN TONS OF 2240 LBS. (a)

	1890.	1891.	1892.	1893.	1894.
To United States	318,108	325,145	278,479	255,603	226,879
To other places	100,617	123,587	117,101	123,569	127,202
Total tons	418,725	448,732	395,580	379,172	354,081

(a) From the Annual Metal Circular of W. T. Sargent & Sons.

The decrease in the shipments to the United States is due partly to the general business depression and partly also to the gradual increase of the tinplate industry in this country. While we import the metallic tin, the iron or steel which favors the basis of the commercial tinplate is made in this country in greater quantities, and the coating of the plates is becoming an industry of importance.

Prices of Tin.

The tables given below show the monthly average of tin prices in the chief markets of the world for the five years from 1890 to 1894, inclusive. For the years prior to 1890 the figures will be found in The Mineral Industry, Vols. I. and II.

PRICES OF STRAITS TIN IN NEW YORK, IN CENTS PER POUND. (a)

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1890	20.95	20.87	20.39	20.13	21.52	21.53	21.17	21.62	24.00	22.60	21.07	21.21	21.42
1891	20.20	19.99	19.75	19.50	20.00	21.00	20.20	20.10	20.25	20.10	20.00	19.90	20.12
1892	20.50	20.00	20.25	20.50	20.80	22.00	21.00	20.50	20.35	20.50	20.80	20.00	20.60
1893	19.99	20.30	20.71	20.81	19.96	19.76	19.15	18.81	20.14	20.84	20.61	20.67	20.15
1894	20.16	19.60	19.09	19.75	20.21	19.75	19.22	19.22	16.27	15.35	14.56	13.81	18.08

(a) From the *Engineering and Mining Journal.*

AVERAGE MONTHLY PRICE OF ENGLISH BLOCK TIN IN LONDON, PER TON OF 2240 LBS. (*b*)

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1890....	99 14 0	95 6 3	94 10 0	94 4 4	97 1 6	99 8 9	97 16 3	98 13 6	102 12 6	101 12 0	96 0 0	95 0 0	97 13 3
1891....	94 1 6	93 5 0	93 5 0	93 0 7	94 10 0	95 13 5	94 17 0	94 6 10	94 2 10	94 5 7	94 15 8	94 6 1	94 4 1
1892....	93 4 0	92 12 2	92 15 9	94 18 7	98 5 0	102 12 0	100 2 0	97 13 9	95 9 0	97 11 10	97 7 6	95 13 4	96 10 5
1893....	95 5 0	95 0 0	97 9 0	96 10 0	93 0 0	89 12 3	86 15 0	84 17 6	84 17 6	83 5 0	80 15 0	79 11 3	88 18 2
1894....	71 18 4	68 15 7	66 19 6	69 17 6	71 13 5	70 7 1	67 7 11	68 19 6	72 1 3	69 1 2	65 8 7	62 4 8	68 14 2

(*b*) For the years previous to 1894, from British blue books. Figures for 1894 are from the Annual Metal Circular of W. T. Sargent & Sons.

MONTHLY AVERAGE PRICES OF STRAITS TIN IN LONDON, PER TON OF 2240 LBS. (*c*)

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1890.....	95 1 0	90 17 10	90 7 6	90 10 7	93 11 0	95 0 7	94 3 9	95 8 3	100 14 4	99 14 6	93 3 2	91 15 7	94 4 0
1891.....	91 1 10	90 3 1	90 6 10	89 16 3	91 13 9	93 3 1	91 17 9	91 11 3	91 11 3	90 19 9	91 8 5	90 15 3	91 4 0
1892.....	89 19 4	89 3 1	89 8 1	91 17 6	95 19 4	100 13 5	97 2 6	94 5 0	92 10 9	94 7 6	94 1 3	92 6 3	93 9 6
1893.....	92 7 6	91 16 3	94 11 6	94 5 6	91 14 4	86 14 0	82 19 4	79 10 0	79 18 9	78 15 0	76 3 0	75 16 3	85 7 7
1894.....	73 2 6	71 2 6	64 15 0	68 7 6	70 10 0	71 5 0	70 1 3	65 7 6	71 7 6	71 2 6	67 2 6	62 13 9	68 18 1

(*c*) From the Board of Trade returns.

PRICES OF BANCA AND BILLITON TIN IN HOLLAND, 1894. (*d*)

Month.	Banca.					Billiton.					Parity of Straits in London.				
	Florins.					*Florins.*					*Florins.*				
January	46¼	45	44½	....	44¾	45	43¼	45⅛	....	43½	45	44	43	43¼	43½
February	44½	43	....	....	43¼	43¼	39¾	40¼	....	....	43¼	39¾	....	....	40¼
March	43¼	41¼	45	44	44¼	39¾	38⅝	41½	....	41¾	39¾	38⅝	41½	....	41¾
April	44¼	....	....	....	45½	41¾	43	42⅛	....	43	41¾	43	42⅛	....	43
May	45⅜	45⅝	45	....	44⅝	43¼	44	42⅝	43¼	43	43¼	44	42⅝	43¼	43
June	44¾	....	....	....	43¼	43	41	43½	....	41¼	43	41	43½	....	41¼
July	43¼	43½	39¾	40¼	40½	41¼	41½	39¾	....	40	41¼	41½	39¾	....	40
August	40¼	41½	44	43	44¼	39¾	40	43¼	....	43½	39¾	40	43¼	....	43½
September	44¼	43¾	43⅛	....	43⅜	43¼	44½	....	....	....	43¼	44½	....	....	....
October	43⅜	40½	....	....	40¾	43¼	40	....	....	40½	43¼	40	....	....	40½
November	40¾	....	38	....	38⅜	40½	37¾	....	....	38⅛	40½	37¾	....	....	38⅛
December	38⅜	37¼	37⅞	....	37½	38	37	....	....	37⅜	38	37	....	....	38⅜

(*d*) Furnished by Messrs. De Monchy & Havelaar of Rotterdam.

AVERAGE PRICE OF TIN AT THE PRINCIPAL MARKETS IN GERMANY. (*e*)

(Price in marks per 100 kilos; 1 mark = 23.8 cents.)

Year.	Frankfurt, Banca, from Dutch Storehouses.	Hamburg, Banca, in Slabs, 2% Discount.
1890	193.75	204.08
1891	186.25	196.90
1892	191.88	201.06
1893	181.33	192.02
1894	144.42	154.23

(*e*) From *Vierteljahrshefte zur Statistik des Deutschen Reichs*, 1894, Part I.

The New York Tin Market in 1894.

Tin has retained its old fame as being the most speculative metal on record, and fluctuations have again been wide, but on the whole the tendency has been of a declining nature. Silver values naturally had a great influence on the price of tin, and a heavy increase in the production, with no corresponding offset in the way of consumption, could not fail to make itself felt to rather a marked degree. This increase in the production was already known to the trade early in the year, and with the pending tariff legislation in the United States, importers and consumers became very careful and carried only such stocks as were absolutely necessary. Thus the market did not receive support from any quarter, and naturally sagged off from week to week, when during the summer information was received from Europe that a syndicate had been formed, evidently influenced by the cheap rates of money and by the low prices then established for the metal, to take up heavy quantities, anticipating that, with the removal of the duty in the United States and an expected improvement in the trade, values would improve, and also that the low prices might check production. Neither of these surmises has proven correct. American buyers are very careful, and whatever contracts were placed for future delivery prior to the change in the tariff contained the stipulation that, in the event of there being a change in the duty, the buyer was to have the benefit thereof. This could easily be granted by importers, as they could store their importations in bonded warehouse, and when on Sept. 1 the duty of 4c., which had been imposed by the McKinley tariff, was taken off and tin restored to the free list, hardly any stocks of duty-paid tin existed in this country.

Deliveries during that month were somewhat larger, but not extraordinarily so, as the bad condition of trade in general did not warrant anybody taking in larger supplies. The heavy shipments which then came forward from the East made the statistical position worse from month to month, and the syndicate (which in the beginning of September had, it is said, accumulated a stock of more than 10,000 tons of tin) rather uncomfortable. Besides, one of the leading houses in London represented in this country undertook an active and successful bear movement. The trade was cautioned not to be influenced by any endeavors to raise prices artificially, and the warnings given prevented losses to a number of people who might otherwise have been induced by the continually cheaper offerings to take in heavier stocks.

In the beginning of November the syndicate evidently found the load too heavy, and let the market take its own course, which then meant a serious decline, and at the end of the year prices touched almost the lowest level ever reached. It is reported that the syndicate is now again entering the market at lower prices, hoping to make up the losses formerly sustained; but with the weak tendency in silver, the enormous accumulations that have taken place in stocks, and the continued large output in the East, it is questionable whether prices have reached bottom. In spite of the low prices, no considerable increase in consumption has been perceptible, and producers and dealers continue to look upon the article with suspicious eyes, and to hold only very moderate stocks.

There is every reason to doubt whether prices would have come down to

where they now are, and whether production would have increased as it has actually done, if Eastern producers did not to-day practically get the same amount of money for their tin as they did a few years ago, which is owing to the lower prices established for silver; and with little or no prospect of seeing silver back again at the old figures, it must still pay very well to produce tin.

The mining of tin in England, in consequence of the general decline, has met with a serious setback, and is now at a point where it is practically no longer remunerative. Production in the United States is *nil*. The mines in California have been abandoned, and the Harney Peak Tin Company, which for years past has been a disturbing factor in the trade, has done nothing, and is in the hands of a receiver.

Nothing has been done in North Carolina, where tin deposits are known to exist, and under the present conditions there is no likelihood that anybody will be found who will take the risk of providing the large capital necessary to develop these deposits.

While thus the outlook from the producers' point of view is not at all cheerful, consumers are able to supply their wants at greatly reduced prices, and in spite of the receding markets they did fairly well during the whole year.

In January prices for pig tin opened at 20½c., and this proved to be the highest price during the year. At that time the stocks accumulated prior to the duty of 4c. going into effect on July 1, 1893, were practically exhausted, and the parity between the London and our own markets, which during the second half of 1893 no longer existed, was again established.

Meanwhile Congress had taken the tariff in hand, and there was hardly any doubt that the obnoxious duty would be taken off. With the heavy receipts and deliveries rather small, prices continued to decline. At the beginning of February 19⅞c. was quoted; the beginning of March showed 18¾c., which was for the time being the lowest point touched, as a better demand then and higher prices cabled from the other side brought about a gradual improvement, and by the beginning of April 19¼c. was reached, but by the end of April 20c. was established, and this price was maintained up to the beginning of June, when the tendency again became a downward one.

At the beginning of July 19½c. was reached; then prices slowly receded, and early in August considerable business was done at 18¾c. With an active demand values then hardened, and by the beginning of September 20c. was again paid. This is the period when the duty was abolished, and prices dropped at once, with the difference in the duty, to 16c. At this time the syndicate bought heavily in London, and a slight improvement took place up to 16⅝c., but for the last three months there was a continual decline.

Early in October the price was 15¾c.; by the end of the month 14¾c.; at the end of November 14½c., and early in December 14c. During December prices declined almost every day, and at the end of the year prices had come down to 13⅜c. and 13½c., with free sellers thereat for spot and delivery over the first six months of 1895.

The statistics show the enormous increase in stocks, which will for the near future continue to be a menace to the market.

The London Tin Market in 1894.

During 1893 it will be remembered that tin, after touching in April £95 10s., was gradually driven back—mainly owing to the financial crisis in America, which stopped the buying for that quarter, and led to realizations of stock with a constant fall in prices—the situation being aggravated by the great decline in silver which ensued on the abrogation of the Sherman act and the closing of the Indian mints to free coinage.

The year 1894 opened without much sign of recovery from the long-standing depression due to the above circumstances, the low silver values enabling producers in the Straits to increase their output and sell at lower prices, while America, in the uncertainty as to the issue of the agitation for tariff reform, was not supporting the market by purchases. The value of Straits tin, under these circumstances, fell from £73 15s. to £71, while in February values collapsed still more rapidly (finally touching £65 10s.), in harmony with the heavy fall in silver and with the large increase in the visible supplies for Europe. The starved condition of the tin plate trade was another factor in the decline, which made further progress early in March, when £63 17s. 6d. was touched. An improvement in silver, and covering by bears then induced a smart recovery, £70 10s. being paid in the first week of April for cash Straits. Large quantities were taken both by London and the Continent during March. A relapse in April to £69 was followed by frequent variations between that price and £70 12s. 6d., the month closing 5s. easier again.

May opened firm on the strength of good statistics, a rise in silver and improved prospects of the abolition of the duty on tin in the United States, and the value went up at a bound from £70 7s. 6d. to £72 15s. This advance was, however, succeeded by a reaction to £70 10s. on the fall which took place in silver. Buyers coming in moderately at the lower range, we had a rally to £71 15s.

June was distinguished by greater steadiness of tone and a narrower range of fluctuations in value, until near the end of the month, when the price fell from £70 to £68 15s. under the influence of persistent offering of forward Straits. Spot tin was relatively more in request.

The main tendency during July was steadily downward. With but trifling checks, the decline made regular progress until the value touched £65 15s. at the close. The main cause of this downward movement was the continued heavy shipments from the Straits.

In August stocks continued to increase, but the passing of the American tariff bill, placing tin on the free list, led to strong speculative buying, resulting in a rise of nearly £7 per ton—from £65 5s. to £72 2s. 6d.—the month closing easier, however, at £71 7s. 6d. Early in September the purchases made by a speculative clique, which had already been some time at work, caused a rise to £74, but the bulls had to fight against determined opposition on the part of some prominent bear speculators, and the market was for a considerable period swayed hither and thither, as the one or the other of these antagonistic parties gained the upper hand. The bears in particular sought to influence the public by circulars and by letters in the journals, evincing much strong feeling. The general sympathies seemed to be rather on the other side, but the bears were

assisted by the heavy supplies and the declining silver market, and September closed with a loss of £3 from the highest figure named, while October witnessed a further heavy fall, influenced by the above factors and by the unsettled state of political affairs. A price of £66 17s. 6d. was reached in the last week of the month, but just at the close a rally occurred; which was assisted by the better figures for October, showing a decrease of nearly 1000 tons in the stocks, and the value recovered to £68 10s. on Nov. 1.

Weaker American advices and the reported stoppage of tin plate works in South Wales were factors which made themselves felt in November, and the resulting depression was deepened by persistent selling, so that the low figure of £63 5s. was touched on Nov. 22, and £62 on Nov. 27. At this lower range of values, consumers evinced more interest in the article and bought pretty freely. This reacted on the speculative market, which rose to £63 7s. 6d., only, however, to fall back again to £62 7s. 6d.

In the first week of December silver declined to 27$\frac{15}{16}$d., and this, coupled with considerable sales of forward tin, depressed the value to £61 5s. spot cash and three months, the lowest point of the year. A sharp reaction occurred at this juncture, three months' Straits tin rising from £61 5s. to £62 12s. 6d., and a strong speculative demand setting in at the beginning of the second week, the rise made very rapid progress, spot touching £63 12s. 6d. on Dec. 11 and £64 10s. on Dec. 12. Sellers showing themselves more than ready to meet the demand and continuing their offers on its subsidence, a sharp reaction followed, which brought the value down again to the lowest point named, the close on Dec. 29 being at £61 2s. 6d.@£61 7s. 6d. for all positions.

The total fall for 1894 in the value of this article has accordingly been £12 10s. per ton, or over £20 per ton for the past two years. In view of the large increase in production in the Straits it would seem, therefore, that it is to consumption that we must look for any solid improvement in this market.

Australian tin has ruled at a premium over Straits, varying from 5s. per ton early in the year up to 12s. 6d. in April, May, and June, and down to about 2s. 6d. at the close. English tin, not being a speculative article, is subject to less frequent and less wide variations than Straits. Bearing in mind that Straits prices are net in warehouse and English f. o. b. and subject to a trade discount, we may say that the latter has been variously quoted during the past year at up to £6 over Straits and down to as low as £1 to £2 over Straits—that is, without deduction of the discount.

Bolivia.—The tin production of Bolivia in 1894, according to returns for which we are indebted to Mr. Robert Peele, Jr., amounted to 4,788,-153 lbs., or 2138 long tons. The output of the Potosi district was 3,929,-886 lbs., nearly all bar tin. The Quechisla mines of Aramayo, Francke & Co., report 248,741 lbs. bar tin shipped and 1,059,589 lbs. barilla (concentrates). As the barilla averages about 80% metal, the total equals 858,267 lbs. metallic tin.

The Quechisla mines also produced in 1894 a total of 401,562 lbs. bismuth.

ZINC.

THE production of metallic zinc or spelter in the United States reached its highest point in 1892, when the total was 84,084 short tons. In 1893 the business difficulties attending the close of the year, combined with strikes and other troubles in the most important producing region, reduced the output to 76,255 short tons, and in 1894 there was a still further fall to 74,004 short tons, showing a decrease from 1893 of 2251 tons, or 2.9%, and from 1892 of 8078 tons, or 9.6%. The decrease was entirely in the first half of the year, when the low prices and uncertainty in the business situation, owing to the tariff discussion in Congress, discouraged production. In July there was a slight revival, which continued throughout the remainder of the year, and in December the output had reached a point equivalent to about 85,000 tons a year, or very nearly that of 1892. Should the conditions continue to improve as they have been doing so far in 1895, it is probable that the output of the current year will be the highest on record.

The decrease was not by any means evenly distributed throughout the different districts. In the mines of Illinois there was comparatively little loss, the falling off amounting to only 777 tons. The Missouri mines, likewise, showed very little decrease, 496 tons being the entire amount, while the new districts in Kansas, which adjoin those of Missouri, showed an actual increase, owing to the opening of new mines and the extension of work in all directions. The largest proportional falling off was on the part of the Eastern and Southern producers, which amounted to very nearly 30% as compared with 1893. The larger part of this decrease, however, was due to the stoppage of the Bertha mine in southwestern Virginia, the largest producer in that State. The mines at Franklin and Ogdensburg in Sussex County, New Jersey, showed but little decrease in activity, and the remarkable deposit of zinc ores in that section kept up its output with very little change.

The abundance of zinc ores in the United States, and the ease with which those in the Missouri and Kansas districts can be mined with small capital, have increased the supply and the competition among producers to a point where it appears that the price must remain permanent at a very low figure. In Europe zinc is used to a greater extent than in the United States for roofing and other

purposes to which it is well adapted, and some efforts to secure its more extensive adoption for such purposes in the United States seems well worth the attention of producers.

The following table shows the production of zinc in the United States for the eleven years ending with 1894 by districts; the statistics for the previous years will be found in THE MINERAL INDUSTRY, Vols. I and II.

PRODUCTION OF SPELTER IN THE UNITED STATES.

States.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Illinois and Indiana	17,594	19,427	21,077	22,279	22,445	23,860	26,279	28,660	30,227	29,725	28,948
Kansas	7,859	8,502	8,932	11,955	10,432	13,658	16,380	21,460	22,953	22,085	26,060
Missouri	5,230	4,677	5,870	8,660	13,465	11,077	13,530	16,205	16,169	13,737	12,000
South and East	7,861	8,082	6,762	7,446	9,561	10,265	11,153	13,938	14,733	10,708	6,996
Total tons of 2000 lbs.	38,544	40,688	42,641	50,340	55,903	58,860	67,342	80,262	84,082	76,255	74,004
Total tons of 2240 lbs.	35,317	36,328	38,072	44,946	49,913	52,553	60,126	71,662	75,073	68,525	66,074
Total metric tons, 2204.6 lbs.	34,967	36,911	38,685	45,669	50,717	53,399	61,094	72,816	76,258	69,159	67,135

In the introduction to this volume will be found an interesting table and diagram showing the production of zinc by months in connection with that of the other principal metals.

The production of zinc oxide declined more heavily than did that of spelter, falling off from 25,000 short tons in 1893 to 20,046 net tons in 1894. The following table will show the imports and exports of zinc in the United States for the five years ending with 1894; the figures being derived from the report of the Bureau of Statistics.

TOTAL EXPORTS OF ZINC AND ZINC ORE FROM THE UNITED STATES (IN POUNDS).

Year.	Ore and Oxide.		Plates, Sheets, Pigs, and Bars.		Manufactures.	Total Value.
1890	8,664,320	$195,113	3,925,584	$126,291	$23,587	$344,991
1891	13,071,840	149,435	4,294,656	278,182	38,921	466,538
1892	2,058,560	41,186	12,494,335	669,549	161,794	877,529
1893	109,760	1,271	7,446,934	413,673	225,357	640,301
1894	.....	5	3,621,934	144,278	99,418	243,701

IMPORTS OF ZINC AND ZINC OXIDE INTO THE UNITED STATES (IN POUNDS).

Year.	Sheets, Blocks, Pigs, and Old.		Manufactures.	Total Value.	Oxide.	
					Dry.	In Oil.
1890	2,112,626	$107,017	$53,469	$160,486	2,631,458	102,298
1891	814,218	41,369	18,424	59,793	2,839,351	128,140
1892	410,896	23,307	22,709	46,016	2,442,014	111,190
1893	425,998	22,301	20,756	43,687	3,900,749	254,807
1894	512,932	17,271	12,342	29,613	.....	.....

An account of the progress of the chief producing districts in Kansas and Missouri will be found in the following pages.

Other Countries.—The foreign production suffered from low prices and a decreased demand as well as that in the United States. The convention under which the European output was restricted remained in force until near the close of the year, but all negotiations for its renewal have so far failed.

The principal producers in Europe are the mines of St. Amand in France, the Vieille Montagne Company in Belgium, the Malfidano mines in Sardinia and the mines of Upper Silesia in Germany. While all of these respected the convention during 1894 several of them extended their works and made preparations for an increase in output during the current year. The Malfidano Company especially has made many improvements in the way of new machinery, concentrators for its low grade ores, and other appliances which will enable it to produce spelter at a very low cost. The Algerian mines have made a small increase in production and new mines have been opened by a French company at Zaghouan in Tunis, which promise to become large producers.

The following tables show the production of zinc in the world for the five years ending with 1894, the production of zinc ore in Europe, and also the production of zinc ore in the Upper Silesian district in Germany for the same period.

PRODUCTION OF SPELTER IN THE WORLD. (*a*) (IN METRIC TONS.)

Year.	Austria.	Belgium.	England.		France.	Germany.	Russia.	Spain.	United States.	Total.
			Native Ores.	Foreign Ores.						
1890.....	5,449	82,701	8,692	20,922	19,372	139,266	3,774	5,919	61,111	347,206
1891.....	5,006	85,999	9,037	20,846	20,596	139,353	3,677	5,592	72,836	363,302
1892.....	5,237	91,546	9,496	21,302	20,609	139,938	4,374	5,925	76,279	374,706
1893.....	5,870	95,665	9,432	19,397	22,419	142,956	4,600	5,752	69,178	375,269
1894.....	.....	.....	.....	.....	.....	.....	.....	.....	67,135	.....

(*a*) Compiled from the official reports of the respective countries, with the exception of the column of zinc in England from foreign ores, which is arrived at by deducting the zinc, as reported in the official blue books, from the total output of the smelting works as stated in the reports of Messrs. Henry R. Merton & Co.

PRODUCTION OF ZINC ORE IN EUROPE.

(In metric tons.)

Year.	Algeria.	Austria	Belgium.	Bosnia.	France.	Germany.	Great Britain.	Greece.	Italy.	Norway. (*a*)	Russia.	Spain.	Sweden
1890	13,091	32,632	15,410	61	47,540	759,437	22,402	33,054	110,926	3,941	44,125	81,398	61,843
1891	13,636	28,828	14,280	47	56,300	793,544	22,580	28,344	120,685	498	47,390	78,216	61,591
1892	21,907	33,944	12,260	16	69,236	800,167	27,311	27,695	129,731	576	.....	74,265	54,981
1893	24,400	30,531	11,310	.....	74,400	787,919	23,880	*b*20,830	132,767	.....	.....	62,616	46,623
1894	.....	.....	.....	.....	.....	728,616	.....	.....	.....	.....	.....	.....	.....

(*a*) Zinc-lead ore. (*b*) Including blende and calamine, calcined.

PRODUCTION OF ZINC AND LEAD ORE AND OF ZINC IN UPPER SILESIA.*

(In metric tons.)

Year.	Blende.	Calamine.	Total Zinc Ore.	Iron Pyrites. (*a*)	Iron Ore. (*a*)	Lead Ore.	Zinc.	Zinc Sheets.	Zinc-White, etc.	Total.	Average Value per Ton of Zinc.
1890	261,921	368,495	630,416	1,949	11,287	32,498	88,699	32,547	896	122,142	$110
1891	271,277	391,891	663,168	2,076	8,088	28,716	88,420	37,669	1,151	127,240	111
1892	291,617	368,230	659,847	2,520	9,371	29,049	88,175	33,266	895	122,336	97
1893	287,395	348,654	636,049	2,107	7,166	30,742	91,716	35,187	211	127,114	79
1894	251,040	323,295	574,335	2,874	5,808	33,898	92,546	34,518	1,267	128,331	69

*From *Statistik der Oberschlesischen Berg- und Hüttenwerke.*
(*a*) Products of the zinc-lead mines.

The state of the industry in Europe was very fully treated in THE MINERAL INDUSTRY, Vol. II. No notable changes in the metallurgy are to be reported.

Prices of Zinc.

The accompanying tables give the average prices of commercial zinc, or spelter, in the leading markets for the five years ending with 1894. For the years previous to 1890 the figures will be found in The Mineral Industry, Vols. I. and II.

AVERAGE MONTHLY PRICES OF SPELTER IN NEW YORK, IN CENTS PER POUND. (*a*)

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1890.....	5.41	5.28	5.18.7	5.08.5	5.35	5.57.5	5.55	5.27.5	5.06	6.01.2	6.12.2	6.10.6	5.55
1891.....	5.55	5.02.5	5.12.5	5.00	4.85	5.08.3	5.06.3	5.01	4.95.8	5.02	4.83	4.75	5.02
1892.....	4.69	4.62	4.89	4.68	4.79	4.71	4.78	4.69	4.53	4.41	4.47	4.40	4.63
1893.....	4.39	4.33	4.28	4.38	4.41	4.27	4.13	3.89	3.69	3.68	3.65	3.80	4.07.5
1894.....	3.56	3.85	3.89	3.62	3.47	3.40	3.43	3.38	3.44	3.45	3.36	3.43	3.52

(*a*) From the *Engineering and Mining Journal.*

AVERAGE MONTHLY PRICE OF ENGLISH SPELTER IN LONDON, PER TON OF 2240 LBS. (*b*)

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1890.....	24 18 0	22 18 9	22 7 6	21 7 2	23 3 6	23 17 2	23 16 3	24 8 6	25 9 8	25 12 9	25 4 4	21 3 9	23 13 11
1891.....	23 9 3	24 6 10	23 18 1	23 10 0	23 9 9	24 3 1	24 7 3	24 3 9	24 8 9	24 5 3	23 11 3	23 2 9	23 18 5
1892.....	22 17 6	22 3 9	21 18 1	23 0 9	23 10 0	23 9 7	22 11 9	22 7 10	20 14 7	19 12 10	19 13 1	19 5 3	21 15 9
1893.....	18 4 1	18 0 4	18 2 10	18 9 4	18 6 3	18 7 10	18 5 0	18 0 4	17 16 9	17 10 0	17 13 7	17 10 9	18 1 5
1894.....	16 8 9	16 2 1	15 14 0	15 15 11	15 14 0	15 10 7	15 18 9	15 11 8	15 10 4	15 5 4	14 14 5	14 9 5	15 11 3

(*b*) The prices for 1894 are from Vivian, Younger & Bond's Metal Price Current. For years previous from the British blue books.

AVERAGE MONTHLY PRICE OF SILESIAN ZINC IN LONDON, PER TON OF 2240 LBS. (*c*)

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1890.....	24 3 0	22 2 6	21 13 9	20 17 2	22 6 9	23 2 2	23 0 7	23 13 3	24 15 3	24 17 9	24 10 4	23 9 4	23 4 4
1891.....	22 15 6	23 12 6	23 5 7	22 15 7	22 15 7	23 10 0	23 14 9	23 8 7	23 14 4	23 12 9	22 16 5	22 9 4	23 4 3
1892.....	22 3 9	21 7 4	21 2 6	22 3 7	22 10 7	22 2 3	21 12 9	21 5 7	19 4 5	18 17 6	18 19 4	18 10 8	20 16 8
1893.....	17 19 4	17 2 6	17 8 11	17 16 8	17 13 6	17 15 4	17 12 2	17 5 8	17 4 2	16 17 4	17 0 2	16 16 7	17 7 8
1894.....	15 16 3	15 16 3	15 16 3	15 11 3	15 11 3	15 17 6	15 10 0	15 11 3	15 6 3	14 18 9	14 2 6	14 2 6	15 6 8

(*c*) For years to 1893, inclusive, from British blue books. The prices for 1894 are from the Metal Price Current of W. T. Sargent & Sons, London.

AVERAGE YEARLY PRICE OF ZINC AT THE PRINCIPAL MARKETS IN GERMANY. (*d*)

(Price in marks per 100 kilos; 1 mark = 23.8 cents.)

Year.	Breslau.		Cologne.	Frankfurt a/M.	Halberstadt.	Hamburg.
	Good Silesian. At Works.	Upper Silesian. Mark CGH. At Works.	Rhenish, Crude. Marks WH & SS. 3 Months.	Refined Calamine and Blende. At Works.	Rhein-Westph., Crude. 1 to 3 Mos. At Works.	Silesian in Plates.
1890.....	45.11	45.00	47.92	47.02	46.58	49.27
1891.....	44.98	.....	47.34	46.44	46.54	48.95
1892.....	40.54	.....	43.08	42.17	42.23	45.30
1893.....	33.60	33.27	35.78	35.13	34.42	38.07
1894.....	29.91	30.01	32.42	30.88	30.87	34.33

(*d*) From *Vierteljahrshefte zur Statistik des Deutschen Reichs*, 1895, Part I.

The prices of 1894, it will be seen, were the lowest ever recorded. The course of these prices and the reasons for the decline are treated in the following pages.

The New York Zinc Market in 1894.

The spelter industry had to bear the full brunt of the general depression which followed the financial crisis of last year. The galvanizing business was for the major part of the year very dull and unsatisfactory, and for nearly three-quarters of the year brassmakers did not take anything like the quantities consumed during the last few years. The most satisfactory outlet for spelter was for sheet zinc, for which most of the time a satisfactory demand existed; but the prices for the rolled metal left hardly any profit for this operation. The new tariff changed the duty on foreign spelter from 1¼c. to 1c. per lb., but as during the last few years spelter could be exported to Europe, and only small consignments were imported for special purposes, this had no bearing whatsoever upon the market in general. Unfortunately, exports during the year were rather small, as prices for spelter in Europe were continually on the decline, and whenever the export point was about reached and small quantities shipped, prices abroad at once declined and made the business unremunerative. At the present time it may be said that the prospects of an export trade in this metal have for the moment entirely vanished, as European prices have fallen to such a low level that it is very unlikely indeed that shipments will be resumed.

Early in the year some of the Western producers pooled their interests by starting a company, the object of which was said to be to regulate the purchase of ores as well as the sale of the refined metal, but after a short time the scheme collapsed, it is said principally on account of dissensions between the different interests represented. In any case this combination somewhat influenced prices during the first half of the year, but it was never able to get a controlling interest in the market, as the outside production was always large enough to supply consumption freely. Besides, as is usual in similar instances and as history has often taught the lesson, whenever consumers think prices are to be artificially raised, they let their stocks run down very low; the output then accumulates at the producers' works, and the stocks thus collected are a constant menace to the market. The result in this case was the usual one, and we understand that the liquidation of the concern was rather disastrous.

Production for the year has fallen off, and it is an undoubted fact that the smelting and refining business in this metal had to suffer very greatly during the year, and only the best equipped and largest works were able to make small profits, while many concerns had to suffer rather heavy losses. This was mostly attributable first of all to the low selling prices which prevailed all along, and secondly to the very high prices which smelters had to pay for ores, and for which much competition usually exists. Not that there were not sufficient ores to meet all current demands, but the particular way in which these ores are mined and sold brings about this state of affairs, and unless consumption increases quite materially during the course of 1895 there is very little hope that matters will greatly differ.

The year commenced with the prices of 3.25c. St. Louis and 3.50c. New York, but after that prices hardened, being to some extent artificially raised by the operations of the combination above alluded to, and by the end of February prices reached the top at about 3.95c. to 4c. New York, or 3.70c. to 3.75c. St. Louis. These prices were firmly held for a few weeks, when consumers bought so little,

and those producers who were not interested in the pool sold so freely that the syndicate, if it may be termed such, was forced to give way, and then the collapse came very speedily.

The beginning of April saw prices at 3.75c. New York, and by the end of the month the price had already declined to 3.50c. In May the market eased off further to 3.37½c., and from then on until the end of July this price was maintained, with slight fluctuations. With a poor consumptive demand and an increase in the production, a further weakening took place during August, but in September prices hardened somewhat and again touched 3.50c. New York, which again proved to be the top, and from that on to the end of the year there was a continual decline, the close being rather flat at 3.05c. and 3.10c. St. Louis and 3.30c. and 3.35c. New York, with sellers over.

It is known to the trade that some of the producers have accumulated large stocks, and although production for the first two months of 1895 may be somewhat less on account of winter interfering with mining operations, the probability is that it will be larger than the demand.

The London Spelter Market in 1894.

The year opened with a decidedly dull market, owing largely to the superabundance of supplies, certain new works being already in active operation, so that despite the arrangement between the older producers the indications pointed to overproduction and a consequent lower level of prices, unless consumption should greatly improve. The opening value was £16 7s. 6d.@£16 10s. ex ship in London, and £17 in Birmingham, for good ordinary brands. The poverty of demand was clearly brought out at the Birmingham quarterly meeting, as also the starved condition of the galvanized iron trade, the result being that, save for a transitory rally of about 5s., there was a steady decline to the end of the month, £16 ex ship, the lowest price since 1888, being finally touched.

February bringing no improvement in consumptive inquiry, and the stagnation in trade being very marked, there was a further fall to £15 12s. 6d. A certain amount of buying on the part of dealers induced a recovery to £16, but on the subsidence of this demand the value relapsed to £15 10s. In the United States the aspect of the market had been rendered temporarily firm by an agreement among the leading makers there to restrict production, but want of unanimity rendered this arrangement very short-lived, so that our market reaped no lasting benefit therefrom. During March the market still remained more or less a dealer's market without special feature, but with values steadier at £15 12s. 6d.@£15 13s. 9d., and early in April, with a shade more general inquiry, the value hardened up to £15 18s. 9d. At this point, American spelter, in moderate quantities, became once more available for export at cheap prices, and as the English makers were also disposed to sell, our market was flattened to £15 15s. May brought little change, but the article, especially toward the close, was more pressed for sale and £15 12s. 6d. was the highest then obtainable. At the beginning of June a somewhat better demand was experienced from wire drawers and wire-netting makers, but the general tendency was weak, and doubts were already expressed as to the likelihood of a renewal of the convention among European producers, after the six months which it had yet to run. The

slight demand referred to was quickly satisfied, and the value fell until £15 5s. had been done. At this juncture it received support in the shape of some vigorous continental buying, and a rapid rise to £15 15s. ensued. This improvement was continued early in July, until £15 18s. 9d. had been done, but on the cessation of continental buying the firmness vanished, and American spelter being again offered for sale, the value fell back to £15 12s. 6d.

In August the relapse continued, there being every disposition to sell, but great reserve on the part of buyers; £15 7s. 6d. was eventually touched, but the month closed about 5s. better, under the influence of a better state of demand for galvanized iron, large shipments being made to South America, while Australia was also buying more freely.

September was a quiet month, with values easier all along the line, £15 7s. 6d. being again accepted ex ship in London, but on the removal of certain distress lots which had been pressing upon the market, a recovery of 1s. 3d. per ton occurred. This slight change for the better was quickly neutralized in October, which proved to be a period of steady decline, the price of £15 being finally broken and £14 18s. 9d. accepted. The Midlands had given no assistance, and the Birmingham quarterly meeting furnished evidence of great depression in all spelter-consuming industries.

In November the rupture of the negotiations for the renewal of the European syndicate caused a thorough collapse, the value falling nearly to £14 5s. A little buying setting in at this low level, a rally to £14 10s. ensued, but in December, with the evident anxiety of some of the continental producers to sell, we witnessed a fresh decline, which again "broke the record," £14 1s. 3d. being ultimately paid. These low prices induced a fair amount of buying by consumers for delivery extended into 1895, and the market recovered to £14 8s. 9d., but closed with a relapse to £14 5s.

The efforts for a revival of the understanding among the producers have so far failed, and there is no probability of a renewal of the agreement which expired with 1894.

The imports of spelter into the United Kingdom for 1894 were 52,901 tons, against 56,926 tons in 1893, and 52,793 tons in 1892.

The Zinc Mines of Southwest Missouri and Southeast Kansas.

By J. R. Holibaugh.

In any review of the mining industry it is necessary to group Missouri and Kansas together, so far as zinc mining is concerned, since the district from which zinc ores are produced extends over adjoining sections of the two States, and it is impossible to divide it by the arbitrary State line. The district, it may be added, also includes a small corner of the Indian Territory.

While of comparatively recent origin, the zinc-mining interest is at present the most important branch of the mineral industry in both Missouri and Kansas. Its history has often been written, but it may be well to repeat here a brief outline. The discovery and opening of the zinc mines of this district occurred 23 years ago, and resulted from the operations of the lead mines. At first but little attention was given to zinc ore, as it had then no particular commercial value; but as lead mines continued to be opened and the zinc ore was found in abundance an effort was made to find a market for it at the zinc works then in operation at Peru and La Salle, Ill. Several shipments of the ore were made, just as it was culled by hand from the lead mines. The treatment of the ore proved it to be of exceptionally high grade and other reduction works commenced to purchase ore from the district. As the first ore was purchased without proving its metal value by assay, and the price of the ore was not determined by the quotations of the metal in the New York or St. Louis markets, the producers fell into the custom of selling their ores to the purchasing agent who would pay the highest price, regardless of the actual value. This was satisfactory to the smelters, while the miners did not seek to change this slipshod way of doing business. The mines, as a rule, were operated under the lease and royalty system by men who had little or no capital. The system of weekly sales and settlements, which gradually became established, was very convenient for these operators. They were enabled to settle their accounts for wages and royalties and to reckon their own profits each week, and all business was closed up at short intervals, so that no elaborate accounts were required. These advantages appeared to most of the operators to outweigh the possible gain from a better system of selling.

During the past year, however, an effort has been made by the Lead and Zinc Association—which is composed of the leading mine operators, land owners and business men of the district—to change the present system of selling ores. They believe that it will be more just, and in the end more advantageous to all concerned, to sell ores on their assay value; prices to be determined by the value of the metal in St. Louis, with proper allowances for transportation and reduction charges. The association, we believe, asks the smelters to name a price for reduction which will allow them a profit on their business and capital invested.

The smelters who draw their ore from the district have not so far seemed willing to concede the terms of the operators, as they prefer the old method of purchasing the ore as cheap as they can. The change, however, will be secured in time, if the operators will stand firm to their demands.

During the second half of 1894 the prices paid by the smelters were higher in comparison to the value of the metal than ever before in the history of the district. At the weekly markets the prices of ores ranged from $15 to $21.50 per ton; in the month of November prices remained firm at from $18 to $20 per ton,

with the demand fully equal to the amount produced. In December there was very little decrease, though the closing week of the year showed less firmness in prices and a less active demand than had been the case earlier in the month.

So far as production is concerned, the zinc district made a much better showing in 1894 than might have been expected. In spite of the general business depression and the apprehension of tariff changes, the total production of zinc ores was only about 6% less than in the preceding year. The year 1893 ended with stocks held by the operators of 5822 tons; at the close of 1894 these stocks were 2885 tons. The total shipments from the district were 142,559 tons, while the total production was 139,779 tons, showing that 2780 tons had been taken from stocks. Of the total shipments we find that there were 12,931 tons of calamine—locally called silicate—and 12,651 tons of this was produced and shipped from the mines at Aurora, Lawrence County, Missouri. The average price paid for the zinc-blende ore for the year was $17.10 per ton, and for calamine $9.35 per ton, making the total value of the shipments $2,337,544 for the year, while the value of the total production was $2,289,906. The value of lead production from the same mines was $1,040,795, making the total value of zinc and lead ore production for the year $3,330,701.

A marked feature of the year has been the amount of new development that has been made in almost every direction. This was largely due to the fact that during the dull times, when many of the large mines were closed down and miners were out of employment, many went prospecting on individual account with the hope of striking shallow deposits of the lead ore, which, as a rule, overlay the zinc ore. In many instances they were successful, so that the area of the district has been greatly increased.

Metallic Contents of Missouri Zinc Ores.—The zinc ores of the Missouri-Kansas district are of exceptionally high grade. The zinc-blende ores of the entire district as marketed are partly concentrated, as it all has to be cleaned by some washing process after it is taken from the mine. The district, indeed, is well supplied with ore-dressing, washing and concentrating plants, ranging from the primitive hand-jig up to large plants with the latest improvements.

As prepared for market and sold, the zinc-blende ores of the entire district will give an average of not less than 56% metal. Some particular districts produce ore that will average 60%, and choice lots are found assaying 66%, being almost chemically pure.

Proportion of Ore to Waste Found in the Mines.—This is a question that is asked by almost everybody who visits the district, and is one of the most difficult questions to answer, from the fact that the richness of the ore deposits is very changeable. They occur in the form of pockets, possibly along fault lines, in both free and desseminated forms. In some cases mines in operation have yielded from 30% to 50% clean ore while working on a rich pocket of free ore; and again a desseminated deposit of ore would be found that would not average more than 10% to 12% clean ore. But few mines can be operated at a profit, if they will not make an average production for the year of 10% ore. The Victor mine at Carterville, Mo., has been working during 1894 on a very large deposit of disseminated ore, which gives an average of only 7% concentrates; but the company is handling a large tonnage and has a large concentrating plant. This mine is the exception to the rule of handling a low grade of rough ore.

THE MINERAL STATISTICS BY COUNTRIES.

In the following tables are collected the statistics of production, imports and exports of minerals, metals, and other mineral products of nearly all the countries of which the statistics were not given in the first volume of The Mineral Industry. Under the title of each substance will be found in this, or in the first and second volumes of the work, the full statistics of that substance and information concerning its production in each country. Though it is sought in this work to avoid repetition of tables as far as possible, yet since it is desirable to have in collected form the statistics of the mineral industry of each country by itself as well as of each substance for all countries, the following tables summarize these national statistics conveniently for reference. The reader should in all cases refer to the subject article in each volume of this work to get the detailed information concerning the world's production, etc., of the particular substance.

While the following tables, like those in the former volumes of The Mineral Industry, are extremely condensed in form, they yet contain, in nearly every case, the full statistics of the industry in each country for the five years ending with 1894. In Volumes I. and II. these statistics were given from the earliest period from which they could be compiled, but in the present volume it was deemed unnecessary to repeat the earlier figures, as they were already upon record in this accessible form. Moreover, the repetition of the figures would have swelled the volume to a greater bulk than was desirable. In all cases where new figures have been secured for substances or countries which were not given in previous editions, they have been presented in full and from the earliest records.

As later statistics are obtainable, the blanks in the tables will be filled in future editions of this work and all necessary corrections made. Future volumes will not only supply any omissions yet existing, and will carry forward the statistics, but will also contain studies of production, of improvements in methods of machinery, and of changes in conditions affecting the industry. The object kept in view has been to make each volume complete in itself and the series a comprehensive history of the mineral industry.

Since the information given in this volume supplements, and does not repeat, that given in the earlier volumes of this work, the reader should in all cases refer to Volumes I. and II. It is greatly to be desired that some uniform system of recording mineral statistics and valueing mineral products be adopted in all countries and we trust this work will lead to earnest effort in this direction.

AUSTRALASIA.

THE mineral industry of the Australasian colonies, which for a number of years had shown a steady and gratifying growth, received a severe setback in 1893 and 1894 from the banking crisis, which produced for a time a general paralysis of credit, and interrupted business operations of all kinds to a degree almost unprecedented in the history of the colonies. While this produced, in several directions, a suspension of work and a consequent decrease in the mineral output, in others the effect was in the opposite direction. All the colonies suffered from this crisis, with the exception of New Zealand, which from its isolated position, its peculiar system of banking and taxation, and the fact that its business relations are almost entirely with England direct, and not with the Australian mainland, largely escaped, and continued to enjoy a moderate degree of growth and prosperity. The crisis was due to a variety of causes, chief among which were over-expansion of credit, the extension of manufacturing and other enterprises beyond the point of a legitimate demand, and the labor troubles which have affected the colonies for several years.

The statistics of Australasia for the years prior to 1890 will be found in THE MINERAL INDUSTRY, Vols. I. and II. In the following pages we give those of the several colonies from 1890 to the latest obtainable date.

New South Wales.—The two leading items of mineral production of this colony are gold and silver. In the production of the former there has been a steady increase since 1890, which was not interrupted by the financial crisis. On the contrary this gave an impetus to the output, owing to the fact that many who had left the gold fields and given up mining and placer working to engage in manufacturing, were forced out of employment, obliged to leave the cities and return to their former occupation. In addition to this, there has been in New South Wales, as in the United States, a marked tendency toward gold mining; new placer deposits and new mines have been discovered; old mines heretofore abandoned have been reopened, while in many existing mines improvements in processes and economies in working have enabled the owners to increase the output.

The coal production of New South Wales reached its maximum in 1891 and has since been gradually declining, partly in consequence of the temporary decrease in the home demand for steam and manufacturing purposes, and partly

also from the increased competition throughout the East with the cheaper Japanese coals, which have largely taken the place of Australian coals in the Chinese ports and the islands of the Indian Ocean.

The silver production of New South Wales, which is drawn from the Broken Hill and the other mines of the Barrier Range, has shown some irregularity in past years. The maximum was reached in 1891, but in the following year production fell off largely on account of the change in the method of mining by the Broken Hill Company, which temporarily reduced the output. The following year again showed a large increase, which has since been well maintained. The future of these mines is somewhat uncertain, owing to the approaching exhaustion of the higher-grade ores. The company has an enormous quantity of low grade sulphide ores, but has not yet reached a conclusion as to the best method of treating these in an economical way, although many experiments have been tried and recently some have given promise of success. The lead production is almost entirely from the silver mines and follows the same course.

The tin production of New South Wales has fluctuated considerably in past years, but still continues an important item in the value of the mineral production of the country. The competition of the tin mines of the Straits Settlements and the increasing production there and in the Dutch islands has affected the Australasian mines to some extent by reducing the price and making it difficult for them to compete with the cheaper labor of their competitors.

In some of the less important minerals there has been, in spite of the drawbacks mentioned above, a fair degree of development. The production of antimony continues to increase. In bismuth, while there have been no additional discoveries, the deposits near Inverell have been worked and have furnished a considerable portion of the supply of this metal. Chrome iron ores from the deposits at Gundagai have been mined and shipped in increasing quantities since the increasing demand and higher prices, which have recently prevailed, have enabled owners of these deposits to mine at a profit. A promising deposit of chrome iron ore has also been found near Orange, but is not yet developed. Several attempts have been made to find chrome ore in the serpentine rocks of the Barrier Range, but so far without success. The deposits of barium sulphate were hardly touched last year owing to the high cost of transportation, and the same thing may be said of soapstone. Mica was mined in small quantities, but the total was hardly large enough to make the industry of importance.

In spite of the attempts made by the colonial government to stimulate the iron industry, no blast furnace has yet been established in New South Wales for working the native ores, and the small quantity of iron reported in our tables is obtained entirely from resmelting scrap and imported metal, and the country is still dependent for its supply upon imports.

The exports of New South Wales are chiefly coal and coke, lead and silver. While most of the gold mined is exported, it is either coined or refined at the Sydney Mint and exported as coin or bullion with the mint's stamp. The imports of raw minerals or metals are not of very great importance, as iron and steel is brought from England and other countries mostly in finished form, as machinery or hardware.

MINERAL PRODUCTION OF NEW SOUTH WALES. (*a*) (IN METRIC TONS; £1=$5.)

Year.	Alunite.		Antimony Ore.		Bismuth		Coal.		Coke.		Cobalt.		Copper Ingots.		Copper Ore and Regulus	
1890....	223	$15,000	1,043	$101,200	2	$1,530	3,110,156	$6,395,445	31,598	$205,735	..	.....	3,216	$817,685	590	$48,870
1891....	715	9,440	930	110,285	40	2,500	4,102,940	8,713,978	30,798	172,365	1	$2,350	3,922	959,390	676	66,075
1892....	834	16,420	740	73,400	14	5,400	3,841,842	7,311,942	8,026	44,260	77	5,550	3,592	802,365	1,320	136,165
1893....	834	16,420	1,803	125,460	..	.....	3,331,764	5,858,610	18,149	101,165	26	1,525	1,068	221,175	1,032	70,955

Year.	Gold, Kilos.		Iron.		Iron Oxide.		Lead.		Limestone Flux.		Manganese.		Shale.	
1890.....	3,973.8	$2,301,434	3,413	$199,740	457	$4,420	128	$7,935	42,104	$209,945	102	$1,625	56,912	$520,517
1891.....	4,769.4	2,791,528	4,192	180,505	233	2,170	194	10,125	75,249	326,785	146	1,700	40,998	390,800
1892.....	4,879.1	2,845,889	2,827	113,025	460	4,345	72	3,630	105,032	465,155	16	235	75,392	680,395
1893.....	5,576.4	3,256,430	2,227	73,930	1,280	7,630	439	21,025	132,764	555,205	....	.....	56,568	506,100

Year.	Silver, Kilos.		Silver-Lead.			Tin Ingots.		Tin Ore.		Zinc.		Sundry Minerals.
			Ore.	Metal.	Value.							
1890.....	15,445	$477,050	91,164	41,985	$13,335,720	3,464	$1,585,585	263	$63,620	214	$11,890	$114,260
1891.....	22,070	674,250	93,871	56,288	17,423,695	2,989	1,308,845	207	48,215	222	13,110	66,935
1892.....	10,907	284,420	88,114	46,588	12,104,760	3,305	1,507,705	243	62,865	452	25,275	35,870
1893.....	16,546	390,655	158,368	59,341	14,767,945	2,830	1,115,695	150	33,020	....	.....	27,850

(*a*) From the Annual Report of the Department of Mines and Agriculture, New South Wales.

MINERAL IMPORTS OF NEW SOUTH WALES. (*a*) (*b*) (IN METRIC TONS.)

Year.	Copper.		Copper Ore.		Hardware.	Iron and Steel.	Machinery.	Tin Ingots and Ore.
1890.....	21	$7,525	14,557	$730,225	$3,106,750	$4,879,135	$2,553,655	$1,288,355
1891.....	3	960	14,837	669,780	3,326,465	7,207,940	2,721,640	1,104,125
1892.....	10	1,860	10,202	509,855	3,173,445	5,394,110	1,544,555	1,186,225
1893.....	.....	.....	.....	.....	.....	.....	.....	.....

MINERAL EXPORTS OF NEW SOUTH WALES. (IN METRIC TONS.)

Year.	Coal and Coke.		Copper.				Hardware.	Tin Ingots.		Tin Ore.	
			Ingots.		Ore and Regulus.						
1890.....	1,863,065	$5,028,295	3,216	$817,685	589	$48,870	$309,050	4,628	$2,119,845	265	$63,795
1891.....	2,560,767	6,569,305	3,922	959,360	678	66,075	261,825	3,948	1,724,450	211	49,490
1892.....	2,226,772	5,141,975	3,592	802,365	1,320	136,165	263,490	3,306	1,507,705	242	62,865
1893.....	1,864,635	4,074,645	1,068	221,175	1,032	70,955	.....	2,679	1,115,685	150	33,020

(*a*) From British Statistical Abstracts. The total value of the mineral products of this colony to the end of 1892 was £98,842,779, the details of which are: Coal, £27,271,429; gold, £39,202,656; silver, silver-lead, and ore, £13,779,931; copper, exported, £6,211,137; tin, exported, £9,840,910; shale, £1,552,796; coke, £84,473; iron, £406,171; antimony, exported, £130,478; pig-lead, exported, £11.049; bismuth, exported, £37,722; zinc spelter, exported, £11,043; limestone flux, £200,378; opals, £17,600; alunite, exported, £8172; building stone, exported, £8043; oxide of iron and pig-iron, exported, £3516; marble, exported, £2577; lime, exported, £1780; cobalt, exported, £1580; ballast stone, exported, £989; manganese ore, exported £712; slates, exported, £351; grindstones, exported, £311; fire-clay, exported, £135; sundry minerals, exported, £56,841.
(*b*) Inclusive of imports overland.

New Zealand.—As noted above, industries of all classes in New Zealand continued throughout the year with less disturbances than in any other of the Australasian colonies. While the progress of the colony has been apparently less rapid than that of some of the others, business has been conducted in a more conservative way and there have been fewer failures. As with New South Wales gold and coal are the two most important mineral industries. The gold production has not increased in recent years, having declined a little since 1891, when it

reached its maximum, partly on account of the working out of some of the large placer deposits and partly because of the refractory nature of the ores encountered in some leading quartz mines. The cyanide process is being tried on a somewhat extensive scale in the islands, but so far no results have been reported. Notwithstanding the decrease, New Zealand remains third in the rank of the Australasian colonies as a gold producer, coming only after Victoria and Queensland.

The coal production has varied somewhat from year to year, but a decrease in exports was shown in 1892 and 1893, owing to the increased competition of other coals in the Eastern markets, to which this fuel is chiefly sent. There was also a decrease in the exports of manganese ores to England, the result of the increased output of the Russian mines which can supply the European market at much lower cost of transporation than the New Zealand production is obliged to pay.

The indications are that the mineral industries of New Zealand will increase with the growth of population and with the extension of railroads and other transportation facilities rather than from any outside demand; while the future of the gold-mining industry depends largely upon the adoption of improved processes.

MINERAL EXPORTS OF NEW ZEALAND. (*a*) (IN METRIC TONS.)

Year.	Antimony Ore.		Coal.		Coke.		Copper Ore.		Gold, Kilos.		Hematite Ore.		Kauri-Gum.	
1890.....	523	$55,605	70,735	$335,015	2,254	$16,670	....	.....	6,009	$3,867,190	1½	$25	7,558	$1,892,815
1891.....	420	24,750	93,140	455,865	2,585	18,290	¼	$20	7,838	5,037,440	....	5	8,523	2,185,280
1892.....	370	24,500	80,181	401,125	4,375	28,455	....	.....	7,405	4,773,720	....	.....	8,845	3,588,390
1893.....	336	17,335	70,249	363,495	51	265	....	.....	7,054	4,565,690	....	.....	8,452	2,553,875

MINERAL EXPORTS—*Continued.*						MINERAL IMPORTS OF NEW ZEALAND. (*b*) (IN METRIC TONS.)					
Year.	Manganese Ore.		Mixed Ores.	Silver, Kilos.		Coal.		Iron.	Machinery.	Railway Materials.	Tools and Implements.
1890....	490	$5,020	$1,365	1,015	$30,810	112,758	$510,830	$2,955,340	$1,094,990	$264,155	$262,660
1891....	1,172	13,170	30	872	25,755	127,325	602,110	2,829,035	1,019,620	142,905	245,870
1892....	529	6,195	3,155	686	19,980	127,460	582,765	3,605,650	1,025,485	120,050	253,390
1893....	324	4,615	3,250	1,961	48,715	127,460	559,780	.....	.....	.....	.....

(*a*) From *Mines Statement*, 1894, by the Hon. A. T. Cadman, Minister of Mines, Wellington. There is no statement of the production of minerals in New Zealand save that of coal (for the statistics of which see article on coal); but the exports practically represent the whole production. The total value of the mineral products of this colony to the end of 1893 was £61,072,410, some of the details of which are: Gold, £49,000,999; silver, £153,887; kauri-gum, £6,860,196; coal, £3,842,408; manganese ore, £56,107; antimony ore, £37,367.
(*b*) From British Statistical Abstracts.

Queensland.—From the early days of mining in Australasia, Queensland has been prominent as a gold producer, and for a number of years past it has held a rank among the colonies second only to Victoria. This fact brings up the total value of its mineral product to a large amount, although its output is less varied in character than that of New South Wales or Tasmania. Some coal is produced in Queensland, although little more than is needed for home consumption. Copper mines have been opened in the colony but never worked to any considerable extent. While some silver ore is raised it does not form an important item in value. The tin production has been fairly steady; although a slight decline in the quantity of tin exported was noted in 1891, there has been a steady

increase since that year. Among the special productions of Queensland are opals, which were found to the value of about $50,000 yearly. Other gems are also found in small quantity.

Gem-mining in the Withersfield district is expanding, and may assume considerable proportions if the several claims and prospecting areas should fully realize the expectations of their owners. The drift that carries the precious stones is fairly rich in zircons, spinnels, and the several varieties of the corundum class, such as sapphires, oriental emeralds, and topazes.

A small quantity of bismuth ore (carbonate) is found in Queensland, but the deposit is somewhat remote from transportation and is but little worked. Some two years ago a discovery of chrome iron ore was reported near Ipswich, but further examination proved it to be of little or no value.

MINERAL PRODUCTION OF QUEENSLAND. (*c*) (IN METRIC TONS; £1=$5.)

Year.	Antimony Ore.		Coal.		Copper Ore.		Gems.	Gold, Kilos. (*d*)		Opal.	Silver Ore.		Tin Ore.	
1890....	175	$24,080	343,791	$785,355	188	$15,000	.....	18,992	$12,211,740	$15,000	1,944	$283,195	3,018	$774,815
1891....	220	18,125	275,949	640,990	100	4,325	.....	17,920	11,528,780	50,000	889	109,395	2,272	581,935
1892....	26	1,390	269,354	616,540	82	12,305	$22,185	19,146	12,311,160	50,000	6,992	182,180	2,427	615,490
1893....	30	1,440	267,091	626,700	302	19,110	22,500	19,187	10,796,450	.....	10,541	212,040	2,522	534,665

MINERAL IMPORTS AND EXPORTS OF QUEENSLAND. (IN METRIC TONS.)

	IMPORTS.			EXPORTS. (*e*)							
Year.	Hardware and Ironmongery.	Iron and Steel.	Machinery.	Copper Ore.		Copper, Smelted.		Tin Ore.		Tin, Smelted.	
1890....	$580,305	$1,402,030	$667,100	87	$12,025	18	$5,090	2,844	$731,350	537	$263,250
1891....	524,010	2,032,240	659,830	36	2,550	87	17,770	1,800	506,525	193	97,000
1892....	413,650	1,094,120	689,675	54	4,470	254	57,445	1,876	177,145	426	198,875
1893....	.....	.....	.....	107	6,420	29	6,475	1,745	444,520	246	119,615

(*c*) From *Annual Report of the Under Secretary for Mines* for 1894.
(*d*) Value estimated at $20 per oz. The gold returns for 1893 show a total output of 600,327 oz., being a decrease of 15,231 oz. on the previous year. The output for the latter half of the year, however, shows an increase of 881 oz. over the first half of the year, the totals being 299,723 oz. and 300,604 oz. The principal yields for the year were: Charters Towers, 256,352 oz.; Rockhampton, 114,039 oz.; Gympie, 78,966 oz.; Croydon, 71,120 oz.; Etheridge, 29,236 oz.; Ravenswood, 9286 oz.; Gladstone fields, 7666 oz.; Eidsvold, 7328 oz.; Palmer, 7175 oz.; Clermont, 4963 oz.; Herbonton fields, 4159 oz.; Paradise, 2491 oz.
(*e*) From British Statistical Abstracts.

South Australia.—As in nearly all the colonies, gold forms in this the most important item of mineral production; but a considerable variety exists in the minerals mined and worked. In the production of copper ore and copper South Australia is second in rank in the Australasian colonies. It has no mineral fuel deposits and draws its supply chiefly from New South Wales. Among the minor products are bismuth, which is found native in a comparatively pure state. Mica of very fine quality is obtained from the MacDonnell range; this product is of unusual size and clearness, so much so, that it is able to stand transportation through a difficult mountain country by camels before reaching the railroad. In addition to the expenses of mining the cost of transportation is said to be as high as $125 per ton. The size of the plates and their clearness and freedom from flaws has made a demand for it for special purposes, and it is shipped entirely to London. A large deposit of graphite was discovered some years ago at Bimbou-

rie, but notwithstanding its extent and the ease of obtaining it, the mineral was found to be too poor in quality to warrant extended operations.

MINERAL EXPORTS OF SOUTH AUSTRALIA. (*f*) (IN METRIC TONS; £1=$5.)

Year.	Copper.		Copper Ore.		Gold, Kilos.		Lead Ore.		Manganese Ore.		Regulus.	
1890	3,009	$777,085	15,628	$357,875	161,243	$104,040	1,062	$84,520	2,808	$35,115	1,176	$104,935
1891	3,609	910,710	13,245	265,875	214,742	136,900	130	8,935	861	8,625	41	2,500
1892	2,769	660,200	10,674	217,425	.....	.....	.....	.....	.....	.....	.....	.....
1893	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Year.	Salt.		Slate, Roofing.		Spelter.		Tin Ore.		Various.		Total.
1890	5,689	$34,015	339,084	$19,540	17	1,305	.....	.....	45	$1,850	$1,520,280
1891	7,628	49,695	170,000	7,100	16	1,135	10	$340	.....	*g*11,495	1,403,310
1892	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1893	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

MINERAL IMPORTS OF SOUTH AUSTRALIA. (IN METRIC TONS.)

Year.	Coal, Coke, and Other Fuel.		Hardware.	Iron—Bar, Sheet, etc.		Iron—Galvanized, Plain, and Corrugated.		Implements Not Agricultural.	Machinery.
1890	232,686	$1,253,645	$157,150	10,270	$426,445	4,634	$422,530	$446,110	$153,585
1891	402,552	2,008,190	238,395	8,874	343,875	7,431	641,875	490,630	153,970
1892	324,954	1,560,880	386,610	6,498	232,305	9,610	605,315	294,860	132,930
1893	.....	.....	.....	.....	.....	.....	.....	.....	.....

(*f*) From the Mining Records of South Australia, British blue books.
(*g*) Includes mica, value $6045, and precious stones $1490.

Tasmania.—This island has been noted from quite an early date in Australasian history for the extent and variety of its mineral wealth, and although this still remains but partially developed the mineral industry is an important and growing one. The tin production, which has been steady and showed but little change for several years, has withstood the competition of the Straits Settlements and the Dutch islands much better than that of the Australian mainland. The gold production, though small in comparison with that of Victoria and Queensland, is nevertheless considerable. In silver ore it stands next to New South Wales as a producer. The copper output so far has not been large, but the copper deposits, especially those of Mt. Lyell, are known to be of great value, and it is expected that within the next few years these will be worked on an extensive scale. Moreover, the range of settlement and exploration in Tasmania is being gradually extended and other mineral deposits may be discovered. While the island is not very large the mountainous nature of the interior and the extraordinarily dense and rapid growth of vegetation have combined to prevent settlement except in districts adjoining the sea; but the interior is becoming gradually better known and more accessible. Several nickel deposits of some importance have been found in Tasmania near Waratah. Silicate ores have been found in considerable quantity, but their working does not promise to be profitable. In the neighborhood of Mt. Zeehan sulphide ores carrying a high percentage of metal have been found and will probably be worked should their exploration show the deposits to be as extensive as is now supposed.

MINERAL PRODUCTION OF TASMANIA. (*j*) (IN METRIC TONS; $1=£5.)

Year.	Coal.		Gold, Kilos.		Limestone.		Silver Ore.		Stones, Building, Cubic Feet.		Tin Ore.		Tin.	
1890..	54,672	$269,060	729	$435,570	3,259	$14,050	2,086	$132,435	115,873	$18,970	4,790	$1,099,340	3,264	$1,483,805
1891..	46,252	227,620	1,219	749,080	5,132	9,245	4,887	261,420	93,838	22,595	4,392	1,309,575	3,329	1,465,850
1892..	36,240	178,345	1,403	870,350	2,253	5,750	9,476	227,510	89,053	21,120	4,737	1,280,415	3,246	1,453,970
1893..	34,587	170,210	1,158	729,375	1,546	3,965	14,530	993,050	37,470	3,965	4,781	1,032,055	3,179	1,301,095
1894..	.....	.....	1,648	993,750	.....	.....	27,700	1,635,760	.....	.....	.....	.....	3,195	1,348,000

MINERAL IMPORTS OF TASMANIA. (*j*) (IN METRIC TONS.)

Year.	Coal.		Ironmongery and Hardware.	Railway Material.	Copper and Lead.	Iron and Tin.	Earthen and Glassware.
1890.....	32,462	$163,615	$672,745	$295,190	$7,875	$211,645	$107,765
1891.....	40,688	200,710	809,110	177,685	9,730	185,260	111,440
1892.....	43,852	227,940	599,765	31,055	8,875	128,875	93,355
1893.....	.....	121,840	.....	57,000	8,205	121,100	51,175

MINERAL EXPORTS OF TASMANIA. (*j*) (IN METRIC TONS.)

Year.	Gold, Kilos.		Tin and Tin Ore.		Silver and Silver Ore.		Copper and Copper Ore	
1890.....	843	$435,425	3,265	$1,483,805	562	$84,360	4	$280
1891.....	1,064	665,065	3,344	1,465,850	2,524	310,990	.....	.....
1892.....	1,164	728,685	3,254	1,453,970	4,440	396,765	.....	.....
1893.....	939	655,520	3,318	1,330,795	13,200	769,260	184	229,830

(*j*) From the Report of the Secretary of Mines and the Appendix A to Statistics of Tasmania for 1893 and 1894.

Victoria.—This colony has been, almost from the first discovery of gold, the largest producer of that, metal and in recent years it has turned out some 40% of the total amount of the yellow metal produced in Australasia. While placer mining is still an industry of considerable importance the chief production now comes from the quartz mines, some of which have reached a considerable depth without in the least reducing their richness. Outside of gold the mineral production is comparatively small. Coal is mined in a few localities only, though in recent years the production has steadily increased. Copper ore, lead and antimony are found in small quantities. Tin ore is also found in small quantities, though of late years its mining has not been profitable and the output has decreased.

MINERAL PRODUCTION OF VICTORIA. (*k*) (IN METRIC TONS; £1=$5.)

Year.	Antimony Ore.		Calcite and Silicate of Aluminum.		Coal.		Lignite.		Copper Ore		Gold, Kilos.		Lead Ore.	
1890.....	132	$15,600	610	$1,500	14,836	$69,495	10,016	$12,500	254	$500	18,307	$11,771,200	51	$250
1891.....	67	5,940	102	25	23,202	98,655	6,424	8,365	61	1,080	17,928	11,527,980	9	45
1892.....	299	11,390	.....	.....	23,739	100,220	6,706	18,625	.....	.....	20,356	13,089,120	.....	.....
1893.....	93	2,155	.....	.....	93,221	245,835	4,573	11,035	.....	.....	20,874	13,414,000	765	.....

MINERAL PRODUCTION OF VICTORIA—*Continued.*

Year.	Silver, Kilos.		Slate and Flagging.		Tin Ore.	
1890..	1,309	$46,290	3,568	$6,060	924	$19,180
1891..	(*m*)	.....	2,311	2,675	1,807	25,460
1892..	16	400	626	900	414	5,195
1893..	1,234	29,915	171	225	54	10,850

MINERAL IMPORTS OF VICTORIA. (*l*) (IN METRIC TONS.)

Year.	Coal.		Iron and Steel.		Iron-mongery.	Rails.	Machinery.
1890..	708,122	$3,727,945	100,050	$4,932,570	$742,530	$812,740	$1,749,635
1891..	861,826	4,189,050	88,106	5,233,515	785,250	52,945	1,283,970
1892..	751,538	3,375,235	61,827	3,687,405	581,065	20,960	776,845
1893..	.....	.....	.....	.....	.....	.....	.....

(*k*) From the blue books of the Mines Department of the colony.
(*l*) From British Statistical Abstracts.
(*m*) There were exported from Melbourne 10.16 tons of silver-lead, valued at $400, and 13.21 tons of ore, valued at $650.

Western Australasia.—Attention has been called to Western Australia within the past two years by the discovery of gold deposits apparently of wonderful richness in the Coolgardie and Murchison districts, and these have been made the basis for a speculation of extraordinary dimensions. It is not yet certain whether these deposits will prove of permanent value or whether they are simply rich pockets of which use has been made by promoters for their purposes. The latter seems the most probable in many cases. That there is gold in Western Australia is proven by the fact that it has been produced there in some quantities for a number of years, and that the output has increased very rapidly since 1891. That the Coolgardie discoveries indicate the existence of leads which will supply material for a permanent industry is not by any means assured.

Western Australia is the youngest of all the Australasian colonies, and moreover labors under the disadvantages of a hot climate and of a scarcity of water over the greater part of its territory. The larger part of its enormous area is practically desert and unexplored. The new gold districts, especially the Coolgardie, are not only remote from transportation and from supplies, but are in the desert region where water is extremely scarce, and where so far the boring of artesian wells and other devices have never yielded a sufficient supply to support life for any considerable number of men, to say nothing of running machinery. The circumstances are extremely unfavorable for mining and only very rich deposits will be able to bear the cost of working. Notwithstanding this, a great number of companies have been organized in London, most of them having paid large sums to the prospectors or promoters of their claims.

The gold industry has been so prominently connected with the name of Western Australia that little has been heard of its other mineral productions; nevertheless there is material for a considerable industry in other lines. Graphite is found of very good quality and will doubtless be mined when transportation is provided, although at present the cost of carrying to market is too great to permit of its profitable use. Mica of very high grade has been found and mined to some extent; it is almost equal in excellence to the South Australian product. There are said to be large deposits of iron ore, but this has not yet been proved.

MINERAL IMPORTS OF WESTERN AUSTRALIA. (*n*) (IN METRIC TONS.)

Year.	Copper.	Coal.		Iron, Pig and Sheet.		Iron Manufactures.	Lead.		Tin.	Zinc.	Soda Compounds.
1891.....	.....	.....	$60,390	.....	.....	.....	.....	.....	.....	.....	.....
1892.....	$1,625	25,607	69,200	2,189	$125,190	$19,453	78	$5,820	$9,160	$2,240	$5,170
1893.....	1,215	19,424	76,010	3,068	145,255	20,854	67	4,875	6,340	3,445	3,890

(*n*) From The Blue Book of Western Australia, 1894.

MINERAL EXPORTS OF WESTERN AUSTRALIA. (*o*) (IN METRIC TONS; £1=$5.)

Year.	Copper Ore.		Gold, Kilos.		Lead.		Lead Ore.		Pearls	Tin Ore.	
1890.....	8*p*	$680	709.36	$433,320	.....	.....	217	$10,675	$200,000	68	$27,025
1891.....	266*p*	22,310	942.79	575,910	.....	.....	25	1,250	200,000	207	51,000
1892.....	576	43,480	1,852.18	1,131,420	.....	.....	29	750	200,000	270	69,215
1893.....	51	3,030	3,449.00	2,106,925	.....	.....	.....	.....	150,000	230	55,670

(*o*) From British blue books and Western Australian Year-Book for 1892-93. The exports represent the production, as practically all ores are exported.
(*p*) Estimated.

AUSTRIA-HUNGARY.

The mineral industry of Austria and Hungary was described with some detail in THE MINERAL INDUSTRY, Vol. II.; the addition of a year's history to the statistics shows but little change.

AUSTRIA.

In Austria the most important single item of production continues to be mineral fuel, the output of which has grown steadily for the past ten years, the total amounting in 1893 to 26,548,606 tons. Of this, however, only 9,732,651 tons were classed as bituminous or true coal, the remainder being brown coal or lignite, which is largely used on account of its abundant supply and cheapness, notwithstanding its inferiority in quality. Iron ore is also an important item in the mineral production, although the output has not shown an increase in recent years; the largest quantity reported was in 1890, since which there has been a gradual decline. This is due chiefly to the increasing quantities of ore imported since the iron industry of the country has remained in a fairly prosperous condition.

The mineral industries of Austria are for the most part protected against foreign competition by differential duties. A number of mining properties are owned by the government, but in recent years the State properties have been run on very much the same principles as the private establishments and have not entered into any special competition with the latter. Some of the older and more noted mines in the country are included in the list of those managed by the government.

An important item of the Austrian production is quicksilver, which is furnished by the mines of Idria, that district being one of the leading sources of the world's supply. Most of the Idria mines are government property.

The oil fields of Galicia furnish a considerable supply of petroleum, the total reaching to 122,000 metric tons in 1893, but the output of these fields does not increase rapidly; it has remained at very nearly the same figure for several years. In these fields the American methods of well-sinking and pumping have been in use for some time and with much success. Apparently no new territory has been reached by the borings of the past year or two, since the production from

new wells has not much more than balanced the loss from wells exhausted or closed.

The silver production of Austria is considerable in amount. The silver mines have continued to be worked steadily notwithstanding the fall in prices of the metal, but new developments have been restricted and the production has remained at very nearly the same figure for several years.

The salt production of Austria is an important item and the salt mines have been famous for many years for their large production and the depth and extent of the workings. These mines are government property and the salt production is a government monopoly in Austria and also in the kingdom of Hungary.

The iron industry of Austria received a considerable impulse from the invention and adoption of the Thomas-Gilchrist steel process, which made it possible to use the native iron ores of Bohemia, Moravia and Styria in the manufacture of steel. The basic steel works at Wittkowicz have been considered as a good example of modern practice in this direction, and there are plants of the same character at other points.

The following table gives the mineral production of Austria for the five years from 1889 to 1893 inclusive; the production for the years previous will be found in THE MINERAL INDUSTRY, Vols. I. and II.

MINERAL PRODUCTION OF AUSTRIA. (*a*) (IN METRIC TONS AND FLORINS.)
(1 Florin = 48 Cents.)

Year.	Alum and Alum Slate.		Antimony Ore.		Arsenic Ore.		Asphalt.		Bismuth Ore.		Coal.		Lignite.	
1889	65,204	42,322	343	39,312	....	.....	369	6,374	773	21,374	8,592,876	26,647,936	13,845,863	22,861,112
1890	58,838	35,998	770	51,880	....	.....	181	2,960	792	19,032	8,931,064	30,401,070	15,329,056	27,639,114
1891	34,394	20,750	333	42,574	4	390	180	2,808	1,083	25,476	9,192,885	32,684,692	16,183,076	30,769,056
1892	20,480	12,863	97	11,765	....	.....	78	1,407	856	22,308	9,241,126	31,680,036	16,190,273	30,096,891
1893	13,370	10,862	441	50,708	....	.....	88	1,301	797	21,818	9,732,651	33,549,863	16,815,955	34,048,957

Year	Copper Ore.		Gold Ore.		Graphite.		Iron Ore.		Iron Pyrites.		Lead Ore.		Mang. Ore.	
1889	7,142	313,698	331	10,376	22,336	702,122	1,115,153	2,487,872	3,539	68,798	12,836	1,137,546	3,926	68,318
1890	7,503	343,422	1,547	18,168	23,728	726,036	1,361,548	3,105,764	3,717	66,596	11,237	969,622	8,007	102,624
1891	9,318	354,574	440	14,440	21,346	693,326	1,231,244	2,854,888	2,831	48,522	13,361	1,068,512	5,279	70,742
1892	8,636	329,824	164	14,886	20,978	637,012	993,290	2,325,088	1,210	25,292	13,265	922,270	4,558	54,830
1893	8,576	316,232	477	43,787	23,807	637,870	1,109,111	2,482,191	1,221	25,199	10,696	849,869	5,411	58,566

Year.	Nickel and Cobalt Ore.		Petroleum.		Quicksilver Ore		Salt.		Silver Ore.		Sulphur Ore.		Tin Ore.	
1889...	.....	.....	112,000	468,000	73,395	850,052	283,553	21,576,780	13,957	3,130,016	9,785	120,444	549	7,274
1890...	0.4	318	122,500	490,000	70,730	891,616	304,084	23,044,927	14,494	3,167,178	5,422	64,624	569	5,168
1891...	.....	.....	123,006	492,150	70,633	1,035,560	301,422	22,639,125	14,538	3,180,882	3,088	37,204	720	3,600
1892...	0.3	.....	120,000	482,000	79,447	1,007,829	288,424	20,796,030	14,171	2,672,606	1,804	20,987	33	2,900
1893...	.....	.....	*b* 122,000	488,000	76,215	735,493	305,856	20,440,426	18,018	3,415,704	1,950	20,485	26	2,741

Year.	Uranium Ore.		Wolfram Ore.		Zinc Ore.		METALLURGICAL PRODUCTION. (*a*)									
							Alum.		Antimony.		Bismuth.		Copper.		Copperas.	
1889.....	16	53,178	20	7,662	30,096	432,910	1,547	112,606	221	75,792	0.1	1,048	863	583,638	1,082	34,040
1890.....	25	41,674	37	12,336	32,642	558,812	1,464	101,632	200	83,584	0.1	1,914	992	602,162	1,296	38,982
1891.....	22	19,314	57	21,380	28,878	575,557	1,127	74,340	115	45,118	0.68	5,606	1,033	584,720	1,184	30,158
1892.....	18	24,889	72	19,806	33,944	580,365	1,096	69,902	114	44,489	0.55	4,765	837	502,593	1,085	31,698
1893.....	21	28,647	43	10,066	30,531	465,230	837	54,344	175	74,090	0.58	5,327	944	568,221	1,220	25,199

Year.	Copper Sulphate.		Gold, Kilos.		Iron, Pig.		Lead.		Litharge.		Nickel and Cobalt Products.		Mineral Paint.	
1889..	158	42,620	13	1,7772	617,012	23,587,454	8,218	1,402,764	2,302	367,238	.....	.....	773	22,004
1890..	438	108,804	21	29,092	666,273	27,300,616	8,297	1,399,494	1,913	296,554	.....	.....	778	22,136
1891..	198	42,286	14	19,272	617,145	24,881,094	7,583	1,206,104	2,267	353,058	1.5	450	838	25,350
1892..	133	24,587	13	17,580	630,790	24,417,266	7,252	1,125,493	2,520	393,356	.15	196	2,022	57,429
1893..	177	35,275	35	52,506	663,345	24,186,083	7,212	1,103,840	2,411	352,648	.12	163	3,020	75,329

Year.	Quicksilver.		Silver, Kilos.		Sulphur.		Sulphuric Acid.		Uranium Salt.		Tin.		Zinc.	
1889.....	566	1,537,014	35.435	3,157,152	40	2,854	9,732	522,356	3.8	79,604	56	70,298	4,840	1,101,028
1890	542	1,596,562	35,862	3,197.584	37	2,642	11,334	441,946	4	64,212	50	59,438	5,449	1,467,840
1891.....	570	1,383,682	36.037	3,219,048	45	3,416	12,268	374,576	4	45,244	56	63,718	5,006	1,375,076
1892.....	542	1,148,320	36,658	3,293,746	53	4,338	11,038	315,433	2	28,398	72	85,184	5,237	1,264,587
1893.....	512	1,068,515	37,344	3,330,265	44	3,613	10,248	336,509	5	74,267	66	76,717	5,870	1,212,709

(*a*) From *Oesterreichische Zeitschrift für Berg- und Hüttenwesen.* Austria also produced in 1893, 1129 metric tons sulphate of iron, valued at 27,934 florins.
(*b*) Estimated.

HUNGARY.

The Hungarian kingdom has been to some extent a mining country from a very early date, and its mines of gold, silver and lead have been known for many years. Nevertheless, the mineral industry is not the leading one of the country although its amount is sufficient to make its value an element in the national prosperity. The gold mines of Hungary have been worked for many years, and still yield a larger amount than those of any other country in Europe. The silver mines are less important than those of Austria; unlike the latter, however, they showed in 1893 a considerable increase in output. In 1894, however, it was decided to restrict the production in those belonging especially to the crown as their working is no longer profitable. Coal and lignite are produced to a considerable extent, although the amount is not sufficient to supply entirely the home demand. Lignite forms about three-fourths of the total fuel production.

The following tables show the mineral production of Hungary for the five years 1889 to 1893 inclusive; the production for the years previous to 1889 will be found in THE MINERAL INDUSTRY, Vols. I. and II.

MINERAL PRODUCTION OF HUNGARY. (*a*) (IN METRIC TONS AND FLORINS.)
(1 Florin = 48 Cents.)

Year.	Antimony Ore. (*b*)		Asphaltum and Asphalt Oil.		Alum Ore.		Coal.		Lignite.		Briquettes.		Coke.	
1889....	174	42,565	.....	.....	1,100	1,635	937,452	4,467,453	1,952,226	5,814,056	22,797	179,855	.....	.....
1890....	224	40,590	.....	.....	525	772	994,812	4,831,308	2,249,098	6,835,016	25,184	198,877	.....	.....
1891....	....	.....	7,649	9,518	1,407	2,060	1,019,352	4,990,356	2,427,126	7,713,443	35,446	275,086	17,124	167,298
1892....	853	72,788	.....	200,000	1,069	1,560	1,052,214	5,174,772	2,741,391	8,085,417	34,882	232,663	2,129	18,951
1893....	881	67,000	.....	.....	.....	.....	982,798	5,161,900	2,917,899	9,394,300	34,190	269,800	3,188	29,300

Year.	Galena. (*b*)		Iron Pyrites.		Manganese Ore.		Mineral Wax.		Nickel and Cobalt Ore.		Petroleum.		Realgar.		Salt.	
1889....	155	26,418	52,416	280,563	98	1,339	570	7,982	366	53,127	68	3,065	169	1,261	164,518	14,432.718
1890....	207	35,266	56,746	294.446	1,445	6,955	1,200	48,000	57	23,270	990	26,407	.....	.....	159,912	13,943,165
1891....	....	.....	57,715	250,349	128	2,357	1,656	94,767	.....	.....	....	.....	0.2	.....	162,788	13,862,083
1892....	....	.....	56,050	236.097	1,304	8,340	.....	.....	340	29,240	20	690	1	.....	163,514	14,119,613
1893....	213	40,500	68,189	277,900	.....	.....	.....	.....	202	18,700	14	600	.....	.....	157,209	14,605,000

Year.	Zinc Blende. (b)		Sulphuric Acid.		Antimony. Crude. (c)	Antimony. Regulus.	Copper.		Copper Sulphate.		Gold, Kilos.	
1889	....	.....	2,059	23,213	333	131,126	305	181,586	205	37,813	2,215.21	2,977.253
1890	77	2,378	1,559	21,956	352	137,184	275	156,836	197	36,864	2,131.35	2,973,041
1891	127	2,650	2,230	60,387	1,370	268,745	247	156,552	....	.....	2,183.92	3,046,440
1892	116	2,825	3,340	54,983	343	138,003	317	165,215	5	1,871	2,246.77	3,134,437
1893	77	1,050	2,337	36,700	361	144,700	343	174,400	2	300	2,000.00	2,790,200

Year.	Iron, Pig.		Iron Sulphate.		Lead.		Litharge. (d)		Nickel & Cobalt Products.	
1889	238,801	8,763,758	244	5,416	2,385	376,190	205	37,814	47	20,984
1890	299,109	11,338,308	87	1,931	1,266	181,945	197	36,864	59	23,449
1891	304,701	11,525,357	540	10,212	2,173	350,230	351	60,988	58	29,240
1892	309,494	11,690,952	595	10,233	2,335	412,558	507	93,884	58	20,272
1893	319,362	12,103,200	762	12,300	2,514	348,600	227	39,600	202	18,700

Year.	Mineral Paints.		Quicksilver, Kilos.		Silver, Kilos.		Sulphur.		Sulphuret of Carbon.	
1889	172	6,694	10,545	25,206	17,229.5	1,532,595	42	2,905	194	30,318
1890	237	6,487	8,102	20,253	17,049.8	1,597,907	63	887	266	30,561
1891	221	8,820	8,631	19,385	16,736.6	1,506,294	40	3,392	174	31,329
1892	263	10,508	7,853	15,641	18,423.8	1,658,143	42	3,773	116	20,208
1893	321	9,600	2,500	4,800	23,631	2,120,000	70	5,900	249	44,800

(*a*) For 1889 and 1890, from *Magyar Statistikai Evkonyv;* for 1891 and 1892, from *Ungarische Montan Industri Zeitung.* In 1890 there was also produced 4 tons of arsenic products (*mireny kovand*), valued at 46 florins. The figures for 1893 furnished by the Hungarian Royal Statistical Office.

(*b*) This does not include the ore produced in Hungary from which the metallurgical products given in the table were derived. It gives only the amount of ore which was sold, and presumably was not smelted in the country.

(*c*) Pure sulphide of antimony prepared by smelting.

(*d*) In 1889 was also produced 141 tons gold glätte, worth 1515 florins.

IMPORTS AND EXPORTS.

The imports and exports of Austria-Hungary are given in the tables below:

MINERAL IMPORTS AND EXPORTS OF AUSTRIA-HUNGARY. (*a*) (IN METRIC TONS.)

IMPORTS.

Year.	Alumin. Alloys, & Manuf'e.	Antimony Regulus.	Asbestos. Crud	Asbestos. M'f'd	Asphalt. Raw.	Asphalt. Ref.	Barytes.	Borax.	Brass Manf'e.	Coal.	Coke.	Charcoal.	Lignite.	Chrome Ore.	Clays. Crud.	Clays. Man'f'd.
1891	42.8	0.4	101	37	1,082	2,022	3,585	1,535	2,269	3,670,196	248,193	1,150	15,174	10	24,115	97,539
1892	49.3	2.1	15	96	1,822	1,442	4,584	852	1,731	3,352,129	254,000	1,023	18,338	10	27.776	{121,632
1893	41.2	.....	97	99	2,144	1,012	4,413	1,451	.....	3,840,874	309,861	853	20,111	570	25,149	.....

EXPORTS.

1891	6.3	276.4	15	27	51	35	192	27	1,138	713,069	73,453	20,238	900.255	157	28,447	47,974
1892	22.9	305.9	9	69	287	.....	33	30	1,234	653,667	87,745	16,181	6,748.844	293	30,882	39,448
1893	28.1	.....	47	187	223	22	35	68	.....	642,424	108,576	14,838	6,763,186	327	31,307	....

IMPORTS.

Year.	Cobalt & Nick. Ore.	Copper. M'f'e.	Copper. Ore	Packfong & M'f'es.	Tomback & M'f'es.	Cryolite. Crud	Cryolite. M'f'd	Fluorspar. Crud.	Fluorspar. M'f'd.	Glass and Glassware	Gold. Coin.	Gold. Metal	Gold. Ore	Graphite. Crude.	Graphite. Ref.	Gypsum, Crude.	Hydrochloric Acid.	Iron M'f'es.
1891	249	9,951	909	349	1	79	52	3,900	444	4,147	23.6	20.7	0.5	691	181	1,657	499	47,623
1892	459	8,337	909	*bd*321	*fh*5	128	73	2,837	275	3,652	29.2	30.8	....	638	93	1,441	460	49,237
1893	971	11,822	638	292	41	131	99	2,782	228	3,599	46.9	62.1	....	782	.....	862	438	.....

EXPORTS.

1891	233	590	10	488	24	10	2	35,524	15	42,788	5.3	65.5	0.3	6,490	4,887	855	1,540	36,502
1892	194	619	19	435	26	14	...	35,187	22	44,093	8.5	41.1	66 4	7,074	4,911	970	1,876	31,782
1893	305	683	14	448	4	2	1	159	63	45,087	9.4	45.5	73.2	7,253	4,284	838	1,841	.....

IMPORTS.

Year.	Iron.				Iron Pyrites.	Iron Sulphate	Kaolin.		Lead.			Lime.		Chlor. Lime.	Manganese Ore.	Marble.
	Ore.	Pig.	Rails.	Spiegel.			Crude.	M'f'd.	Lead, Alloys, M'f'e.	Litharge.	Ore.	Crud.	Hydraulic.			
1891	68,121	40,743	705	104	30,770	745	2,827	1,221	4,561	250	283	7,536	16,744	867	425	1,494
1892	71.679	45,843	333	920	32,261	1,424	2,154	1,622	7,348	316	355	8,558	18,931	1,016	519	1,939
1893	73,248	57,733	927	697	45,530	800	2,273	1,874	6,286	316	299	9,115	17,098	1,559	354	1,816

EXPORTS.

1891	88,059	8,394	253	294	8,539	747	5,811	34,881	255	1,007	3,658	19,924	58,750	311	8,364	3,041
1892	108,120	7,932	161	1,153	6,833	417	16,988	30,185	202	1,334	3,784	14,432	59,784	38	3,768	2,389
1893	106,259	9,274	20	371	3,042	476	23,624	26,192	270	1,311	1,608	28,019	66,543	216	3,697	2,688

IMPORTS.

Year.	Oil, Mineral.		Paint, Min'l.		Nickel and Manufacture.	Peat.	Phosp. & Phos. Ac.	Platin. & Oth. Prec. Metals.	Potassium.	Chlor of Potassium.	Nitrate of Potassium.	Quicksilver.	Salt.	Silver.			Slag.
	Crude.	Ref. or Partly Refined	Crud.	Ref.										Coin.	Metal.	Ore.	
1891	122,790	16,735	1,718	2,409	52	2,485	217	0.05	767	1,917	27,199	17	26,801	49	79	22	426
1892	135,823	14,479	1,295	2,165	*h*46	2,935	200	2.1	164	1,945	28,071	2	27,836	60	88	0.5	3,621
1893	139,168	16,764	1,680	3,147	*h*51	2,228	238	.....	.....	1,869	37,626	3	26,609	59	58	0.1	1,659

EXPORTS.

1891	443	2,188	1,138	1,605	83	2,712	1	0.7	5,157	315	44	488	4,861	31	120	10	84,484
1892	576	1,873	1,169	1,232	237	5,101	1	3.3	6,001	925	11	465	10,088	79	127	23	49,647
1893	613	3,767	922	1,409	79	5,441	6	1.2	.....	1,118	15	414	7,678	87	131	14	45,478

IMPORTS.

Year.	Soda.			Glauber Salt.	Stone Quartz, Etc.	Stoneware.	Stucco.	Sulphur.	Sulphuric Acid.	Tin and Manufacture.	Vari. Min'ls.		Various non-Prec. Metal and Manuf'e.	Various Ores.	Zinc.	
	Calcin.	Caustic	Crude & Crys.								Crud.	Gr'd or Tre'd.			Ore.	Spelt, M'f'e.
1891	1,391	690	911	5,484	115,893	42,711	7,544	14,939	2,689	2,378	49,704	38,840	1,484	327	104	11,715
1892	807	1,316	197	5,389	117,773	55,477	7,925	13,900	1,909	2,406	46,506	40,266	*h*1,417	432	3,481	14,724
1893	953	.....	.....	6,688	155,571	70,394	.....	13,090	2,090	2,921	50,722	455,478	.....	401	3,739	15,529

EXPORTS.

1891	1,063	626	806	78	315,857	37,731	1,814	352	3,953	125	25,773	34,085	3,380	1,283	7,766	1,184
1892	1,048	202	271	77	260,946	36,943	1,766	474	2,855	144	21,598	35,405	3,400	905	12,578	1,442
1893	608	.....	323	570	272,239	36,743	.....	1,508	3,906	150	118,665	33,642	.....	619	7,578	1,939

(*a*) From *Statistische Uebersichten betreffend den auswärtigen Handel des oesterreichisch-ungarischen Zollgebiets, Wien.*

The coal and coke imported are chiefly used in the iron works of Bohemia and Moravia. The other minerals call for no especial remark.

Of the exports recorded above, coal and lignite form a large portion. The lignite exported goes chiefly to the adjoining provinces of Germany. The same may be stated of the iron ore exported, almost all of which is sent to Germany.

BOSNIA.

The production of Bosnia, which is under Austrian rule, though still considered a separate state, is given in the following table:

MINERAL PRODUCTION OF BOSNIA. (*a*) (IN METRIC TONS AND FLORINS.)

Year.	Chrome Ore.		Lead-Silver Ore.		Lignite.		Manganese Ore.		Salt.		Zinc Ore.		Antimony, Crude.		Copper.		Pig Iron.		Quicksilver.	
1890	1,000	10,800	92	800	59,906	49,080	5,500	36,801	5,000	140.000	61	248	36	5,480	134	28,400	230	3,640	5.3	6,360
1891	918	10,030	109	2,280	77,266	66,160	8,847	58,000	5,970	167,660	47	188	27	2,720	160	32,000	987	11,200	5.2	5,560
1892	1,296	14,411	41	1,680	85,449	76,049	7,944	51,203	8,006	224,000	16	64	91	6,240	140	26,602	3,173	41,360	0.3	281
1893	965	10,996	...	.....	118,263	113,434	7,403	44,265	8,517	238,476	...	...	3	198	101	19,796	2,816	36,613	0.2	600
1894	1,808	36,890	...	.....	160,800	414,100	6,588	104,085	10,250	779,000	...	...	...	.....	270	135,197	3.287	107,477	...	.....

(*a*) These figures were kindly furnished by C. von Ernst of Vienna. There has also been produced: Antimony ore, in 1891, 108 tons; 1892, 276 tons. Quicksilver ore, in 1891, 88 tons; 1892, 3.5 tons. Also from *Montan Zeitung für Oesterreich-Ungarn:* Produced in 1893: Quicksilver ore, 0.886; copper ore, 2.365; iron ore, 6.874; antimony ore, 0.089; fahl ore, 0.318; iron pyrites, 0.700; coal, 122.396; iron (pig), 45.16, and salt, 85.51 tons.

The mineral production of Bosnia, which is of considerable importance, had hardly any records prior to the occupancy of the country by the Austrians in 1878; since then the industry has been largely developed. The old mines have been reopened and new ones have been discovered and explored. The oldest mines in this Province of Austria are the silver mines, which were worked by the Ragusians in the middle ages, and had then a considerable reputation. The production, however, does not now reach a large amount as many of the older mines are exhausted, and under present circumstances the reopening of the deeper mines would hardly pay. No true coal is produced in Bosnia, but a considerable amount of lignite is mined. The manganese ore is of excellent quality and there is a considerable quantity; much of it is absorbed by the Austrian and Hungarian steel works. Among the other productions of Bosnia are chrome iron ore; also antimony ore and a small amount of copper; salt sufficient for the home consumption is also produced, but this is a government monopoly, as it is likewise in Austria. Upon the whole, the mineral industry of Bosnia is in a fairly prosperous condition, and is growing as the country is gradually developed. Under its new rulers in some respects important changes have been made. The iron manufacture, which was under Turkish rule conducted in small furnaces or bloomeries, has come almost entirely to an end, and the pig iron produced is the output of a modern blast furnace which has been erected at the mines of Vares.

BELGIUM.

BELGIUM has always been noted for the extent and activity of its mineral industry, and no country has been able to show so large a production from so limited an area. The mines of Belgium furnish zinc, iron ores and coal in abundant quantities, and also some lead and silver ores, which are found chiefly in connection with the zinc mines. In addition to this the quarry production is very considerable, furnishing paving and building stones, sand, clays of various sorts, and slate, while the deposits of phosphate of lime are among the most important in Europe. The metallurgical industry is also a very active one, and the production of fuel and iron ores is not only utilized at home but some importations are necessary to supply the iron and steel works. The following tables show the production of Belgium for the five years from 1889 to 1890 inclusive; the statistics for the years previous to 1890 will be found in THE MINERAL INDUSTRY, Vols. I. and II. The production is arranged under different heads, the mineral and metallurgical products being given separate from the quarry output, while the coal production will be found in a fourth table.

MINERAL PRODUCTION OF BELGIUM. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Blende.		Calamine.		Total Zinc Ore.		Iron Ore.		Iron Pyrites.		Lead Ore.		Totals.
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Value.
1889.....	10,248	$146,400	10,936	$112,800	21,184	$259,200	202,431	$272,600	5,051	$8,600	194	$4,000	$544,400
1890.....	10,370	174,400	5,040	65,600	15,410	240,000	186,546	251,800	2,980	5,600	150	3,200	500,600
1891.....	10,200	163,280	4,080	47,410	14,280	210,690	*b*202,204	234,540	1,990	3,820	70	1,620	501,540
1892.....	8,250	126,880	4,010	49,440	12,260	176,320	*b*209,943	218,620	2,570	5,480	60	1,640	463,720
1893.....	7,300	83,720	4,010	43,440	11,310	127,160	284,465	295,580	6,301	9,800	67	1,520	561,220

METALLURGICAL PRODUCTION OF BELGIUM. (*a*) (IN METRIC TONS AND PRICE PER TON.)

Year.	Forge Pig.		Foundry Pig.		Manganiferous Pig.		Bessemer Pig.		Thomas Pig.		Castings.		Total Pig.	
1889.....	586,776	$9.74	59,676	$12.36	4,065	$19.53	165,493	$13.12	15,116	$11.54	1,100	$20.69	832,226	$10.69
1890.....	526,644	11.64	69,183	13.51	1,786	17.03	164,943	15.60	24,210	13.18	1,070	25.42	787,836	12.71
1891.....	445,436	10.18	56,241	11.78	.....	.....	147,913	14.01	34,536	11.40	.....	.....	684,126	11.20
1892.....	442,009	9.15	67,236	9.62	.....	.....	190,599	13.09	53,424	10.39	.....	.....	753,268	10.28
1893.....	428,480	9.00	74,630	9.54	.....	.....	165,077	11.59	77,077	9.47	.....	.....	745,264	9.66
1894.....	408,086	9.00	80,110	.....	.....	.....	322,744				.....	.....	810,940	.....

Year.	Wrought Iron.		Cast Steel.		Rolled Steel.		Lead.		Silver, Kilos.		Zinc.	
1889	577,204	$28.00	261,397	$19.66	214,561	$27.20	9,412	$62.11	24,622	$31.22	82,526	$93.06
1890	514,311	32.27	245,566	22.97	201,817	30.99	9,617	65.28	33,083	35.10	82,701	111.76
1891	497,380	29.20	243,913	19.63	206,305	28.22	12,698	61.35	33,950	32.76	85,999	112.26
1892	479,008	27.09	260,037	17.90	208,281	26.50	10,146	53.03	30,267	28.94	91,546	101.74
1893	485,021	25.51	273,113	16.79	224,922	25.67	12,006	51.23	26,717	25.79	95,565	82.79
1894	453,391	.....	396,914	.....	344,776	.....	.....	.....	.....	.....	.....	.....

(*a*) From *Statistique des Mines, Minières, Carrières, et Usines Métallurgiques.* Figures for 1894 estimated by Mr. Emil Harzè.
(*b*) Does not include ferromanganese, which amounted to 18,498 tons and 16,775 tons ($50,092 and $41,660), respectively, in 1891 and 1892.

QUARRY PRODUCTION IN BELGIUM. (*c*) (VALUES IN DOLLARS.)

Year.	Building Stones.		Chalk, Marl.		Dolomite.		Flagstones.		Limestone for Flux.		Marble.	
	Cubic Meters.	Value.	Cubic Meters.	Value.	Tons.	Value	Sq. Meters.	Value.	Cubic Meters.	Value.	Cubic Meters.	Value.
1889	1,886,212	$3,730,800	13,980	$19,000	2,150	$1,000	138,180	$86,400	122,925	$44,200	11,605	$351,600
1890	1,874,340	3,798,200	114,400	48,800	2,650	1,200	129,848	82,600	140,720	48,600	12,122	427,400
1891	1,737,951	3,502,800	38,075	28,600	1,500	600	123,875	76,200	197,365	61,600	11,350	441,800
1892	2,502,692	3,980,800	32,610	26,600	3,100	1,800	105,793	67,400	140,800	55,800	11,750	455,400
1893	2,645,622	4,285,000	46,295	28,400	3,500	1,400	90,780	52,800	166,425	70,200	13,147	506,800

Year.	Paving Stones.		Phosphate of Lime.		Plastic Clay.		Quartz Gravel.	
	Pieces.	Value.	Tons.	Value.	Tons.	Value.	Cubic Meters.	Value.
1889	80,247,400	$1,352,000	218,980	$838,000	191,650	$316,600	567,950	$250,600
1890	72,913,700	1,421,800	301,210	1,093,800	215,592	343,600	632,430	259,600
1891	86,158,700	1,517,200	291,080	1,006,000	222,760	279,200	465,380	228,000
1892	88,048,700	1,497,800	268,210	756,000	276,855	341,800	18,100	10,400
1893	96,041,650	1,714,000	331,230	881,000	192,262	287,200	7,280	3,800

Year.	Sand.		Silica for Pottery.		Slate.			Sulphate of Baryta.		Whetstones.	
	Cubic Meters.	Value.	Cubic Meters.	Value.	Pieces.	Cubic Meters.	Value.	Tons.	Value.	Pieces.	Value.
1889	294,068	$127,200	22,400	$43,600	27,115,000	640	$135,600	9,800	$10,800	.....	.....
1890	316,419	107,600	25,900	45,800	30,951,500	140	166,200	9,800	10,800	.....	.....
1891	328,731	126,000	34,300	65,400	31,569,000	220	189,400	20,000	16,000	*e*130,000	$24,400
1892	383,545	163,600	*d*38,370	48,800	33,903,000	415	224,400	42,000	56,800	*e*153,000	38,000
1893	389,970	130,800	32,850	40,400	32,508,500	615	212,800	41,500	58,200	100,000	9,200

COAL PRODUCTION OF BELGIUM.

Year.	Metric Tons.	Value.	Per Ton.	Profit, Per Ton.	No. of Workmen.	Annual Wages.
1889	19,869,480	$37,543,600	$1.89	$0.22	108,382	$186
1890	20,365,960	53,700,600	2.64	.58	116,779	223
1891	19,675,664	49,490,800	2.52	.36	118,983	217
1892	19,583,173	40,257,600	2.06	.12	118,578	191
1893	19,410,519	36,281,180	1.87	.07	116,861	177
1894	20,457,827	.....	.....	.....	.....	.....

(*c*) From *Statistique des Mines, Minières, Carrières, et Usines Métallurgiques.* (5 fr. = $1.) Belgium also produced, in 1893, 880 tons of ochry earth, worth $1400, and 1800 tons of feldspar, worth $3200.
(*d*) Excluding kaolin produced in 1892, 750 cubic meters, $1600.
(*e*) Excluding grindstones produced in 1891, 90 cubic meters, $400; in 1892, 17,100 cubic meters, $3400.

An interesting statement showing the consumption of zinc, lead, iron and steel in Belgium will be found below as prepared by the statistical department of the country. It will be seen that the consumption of pig considerably exceeds

the production. With zinc, however, the consumption is not much more than one-fourth of the output.

CONSUMPTION OF CERTAIN METALS. (*a*) (IN METRIC TONS.)

Year.	Lead, Unwrought.	Iron.		Steel.		Zinc, Unwrought.
		Pig.	Finished Products.	Ingot.	Finished Products.	
1890	18,232	1,022,329	251,260	253,147	98,150	20,917
1891	22,718	814,666	226,737	249,529	126,432	24,945
1892	16,501	815,436	207,858	267,939	130,061	20,659
1893	20,087	885,343	234,103	290,640	112,684	25,670

(*a*) From *Statistiques des Mines, Minières, Carrières et Usines Métallurgiques.*

IMPORTS AND EXPORTS.

The mineral imports of Belgium consists chiefly of coal and coke and iron ores which are needed to make up the deficiency in the native product. Some pig iron is imported, chiefly from Luxemburg, and a considerable quantity of lead. Salt also forms an item of considerable quantity.

MINERAL IMPORTS OF BELGIUM. (*a*) (IN METRIC TONS.)

Year	Coal.		Briquettes.		Coke.		Lime.		Iron Ores, Iron and Steel Filings.		Sulphur.		Various.
1889	1,004,624	$2,893,370	1,345	$4,008	18,545	$74,922	35,313	$77,600	1,805,250	$4,332,800	51,771	$2,070,800	$7,649,200
1890	1,719,534	6,018,369	1,704	6,986	65,339	341,854	36,311	79,800	1,164,548	3,947,600	42,309	1,692,400	9,563,200
1891	1,621,065	5,608,885	3,686	15,112	140,576	598,854	25,378	55,800	1,534,609	3,071,400	33,020	1,320,800	10,282,400
1892	1,486,212	4,607,257	5,542	17,734	191,054	668,689	25,884	57,060	1,679,485	3,191,200	24,973	899,000	9,979,800
1893	1,288,640	3,865,920	5,545	17,467	287,560	983,455	29,460	58,920	1,684,679	3,200,997	17,838	642,156	8,480,880

Year.	Various Other Metals.	Stone.		Chemical Products.	Glass and Glassware.(*b*)	Salt, Coarse.		Salt, Refined.	
1889	$1,800,400	.....	.....	$15,093,200	$332,600	78,117	$468,400	32,320	$323,200
1890	1,498,000	54,433	$762,000	11,928,200	409,800	64,031	384,200	39,100	391,000
1891	2,159,800	59,042	826,600	13,780,400	409,800	79,422	476,600	39,586	395,800
1892	2,002,600	76,491	1,242,600	14,845,800	416,000	86,330	518,000	34,162	341,600
1893	1,622,947	49,648	747,918	16,520,549	487,560	84,524	507,145	39,561	395,612

IMPORTS OF METALLURGICAL PRODUCTS. (IN METRIC TONS.)

Year.	Steel.		Copper and Nickel.		Iron, Pig and Scrap.		Iron, Wrought.		Gold, Silver and Platinum Jewelry.	Lead.		Zinc.	
1889	12,376	$738,800	7,550	$2,635,600	263,357	$3,027,000	24,070	$967,200	$662,800	30,312	$2,425,000	5,113	$429,400
1890	13,517	665,600	7,386	2,580,800	264,275	3,435,600	23,136	985,200	755,200	35,985	2,878,800	5,242	440,400
1891	13,174	599,000	8,269	2,199,800	205,482	2,401,000	25,286	987,200	678,200	34,093	2,044,600	6,972	794,800
1892	18,647	838,000	8,222	2,056,400	174,177	1,970,600	24,321	885,200	764,200	31,054	1,614,800	5,936	617,400
1893	29,818	1,190,643	8,025	1,968,962	186,198	2,107,443	30,817	1,169,399	874,566	38,028	1,901,420	5,833	501,632

(*a*) From *Annuaire Statistique de la Belgique.* The figures for 1893 furnished by Mr. E. Harzé, *Ingenieur Principal au Ministére de l'Interieur.*
(*b*) The quantities of crushed glass imported were 820 tons in 1890, 841 tons in 1891, and 1178 tons in 1892.

While Belgium imports coal and coke it also exports a portion of its output, chiefly to the districts adjoining the frontier in France. The quantity of pig iron exported is not large, but wrought iron and steel in various forms are a considerable item. The Cockerill works at Seraing and Hoboken have long been famous for their railroad material, machinery and ships, while other establishments have almost an equal reputation. The Belgian works have

always commanded a large foreign trade on account of the excellent quality and cheapness of their products, and they still continue formidable competitors with the other countries of Europe. Zinc is a large item in the exports, both in quantity and value; the Belgian mines supply a considerable part of the European demand.

MINERAL EXPORTS OF BELGIUM. (IN METRIC TONS.)

Year.	Coal.		Briquettes.		Coke.		Lime.		Iron Ores, Iron and Steel Filings.		Sulphur.		Various Other Minerals.
1889	4,279,700	$12,325,536	317,164	$945,149	1,219,959	$4,928,634	328,024	$721,600	157,908	$270,600	4,528	$181,200	$3,563,200
1890	4,533,785	15,868,247	317,628	1,302,275	1,064,759	5,570,819	357,474	786,400	174,231	295,200	4,232	169,200	5,288,800
1891	4,750,232	16,435,803	358,691	1,470,633	933,668	3,977,426	373,671	822,000	194,933	370,200	4,071	164,800	5,958,600
1892	4,539,485	14,072,403	351,570	1,125,024	991,018	3,468,598	385,399	847,800	228,804	454,000	3,868	139,200	5,446,600
1893	4,849,887	14,549,661	489,225	1,541,059	941,663	3,220,487	404,039	808,078	172,967	339,902	4,609	165,918	6,125,735

Year.	Steel.		Copper and Nickel.		Iron, Pig and Scrap.		Iron, Wrought.		Gold, Silver, and Platinum Jewelry.	Zinc.	
1889.....	118,217	$6,288,400	3,751	$1,390,800	22,573	$288,800	412,453	$14,707,400	$30,200	67,489	$6,344,000
1890.....	109,604	5,811,200	4,671	1,692,800	23,165	301,200	356,109	13,585,000	21,600	67,026	6,300,400
1891.....	87,431	4,524,800	4,674	1,318,200	23,963	317,600	359,740	12,182,200	17,000	68,026	7,755,000
1892.....	98,867	5,189,000	4,659	1,186,800	27,748	355,000	337,999	10,752,000	29,600	76,823	7,989,600
1893.....	114,530	7,633,447	5,480	1,447,589	28,017	464,702	318,197	9,276,604	.....	76,296	6,614,164

Year.	Lead.		Various Metals.	Stone.		Chemical Products.	Glass and Glassware.	Salt, Coarse.		Salt, Refined.	
1889.....	20,070	$1,605,600	$584,200	829,615	$11,614,600	$7,039,600	$9,268,000	248	$5,400	216	$2,200
1890.....	27,370	2,189,600	493,200	911,258	4,556,200	7,035,800	9,026,800	341	2,000	106	1,000
1891.....	24,073	1,414,400	521,800	872,937	4,364,600	7,011,200	9,054,800	1,216	7,200	152	1.600
1892.....	24,709	1,284,800	622,200	927,767	5,504,000	8,019,800	8,887,600	1,118	6.800	228	2,200
1893.....	29,947	1,497,358	544,178	1,112,273	5,419,974	8,683,269	9,902,816	556	3,339	148	1,484

In some cases the mines of Belgium, especially those of coal and iron ores, are beginning to show signs of exhaustion; some coal mines, for instance, are reaching so great a depth that much longer continuance of their operations with profit is doubtful. This was to be expected from the activity of the industry above referred to, the mineral area being necessarily so limited that its early exhaustion was to be expected, and it seems probable that before many years have passed the finished product of Belgium will be largely manufactured from imported raw materials.

CANADA.

THE mineral production of Canada is a varied and, in some directions, an important part of the wealth of the Dominion. The resources of the country are as yet but partially developed, the iron industry especially having grown but slowly, though the country has many valuable deposits of iron ores and a sufficient supply of fuel. At present nearly all the iron and steel produced is in the New Glasgow and Londonderry works near the Atlantic coast. Of one metal—nickel—the Canadian mines at present furnish the chief supply of the world.

Through the courtesy of the Geological Survey of Canada we are enabled to present very full and recent statistics, the figures for 1894 being from advance sheets of the annual reports furnished us by Mr. Elfric Drew Ingall of the Survey, under whose direction the figures were prepared. The statistics for five years are given in the following tables; those for the year previous to 1890 will be found in THE MINERAL INDUSTRY, Vols. I. and II.

MINERAL PRODUCTION OF THE DOMINION OF CANADA. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Antimony Ore.		Arsenic.		Asbestos.		Baryta.		Bricks, Thousands. (*b*)		Building Material. Stone, Cu. Yd. (*b*)		Building Material. Flagstones, Sq. Ft.	
1890.....	23	$625	23	$1,500	8,947	$1,260,240	1,671	$7,543	211,727	$1,266,982	382,563	$964,783	17,865	$1,643
1891.....	[g]	60	18	1,000	8,167	999,878	.....	.....	176,533	1,061,536	187,685	708,736	*d*24,766	2,721
1892.....	....	.....	....	.....	5,518	390,462	286	1,260	202,147	1,251,934	219,747	609,827	13,700	1,869
1893.....	....	.....	....	.....	5,743	310,156	.....	.....	290,000	1,800,000	*c*219,747	609,827	40,500	3,487
1894.....	....	.....	6.4	420	6,935	420,825	.....	.....	.....	*c*1,800,000	.....	1,100,000	152,700	5,298

Year.	Building Material—*Continued.* Granite.		Building Material—*Continued.* Marble.		Cement, Barrels.		Fire Clay.		Pottery.	Tiles and Sewer Pipes. (*b*)	Coal.		Coke.	
1890....	12,075	$65,985	708	$10,776	102,216	$92,405	....	.....	$195,242	$488,877	2,829,093	$6,496,110	51,225	$166,298
1891....	9,977	70,056	217	1,752	93,473	108,561	227	$750	258,844	368,699	3,085,734	8,144,247	51,800	175,592
1892....	22,047	89,326	308	3,600	117,408	147,663	....	3,567	265,811	558,517	2,986,999	7,184,510	*f*50,926	160,249
1893....	20,431	94,393	535	5,100	158,597	194,015	490	700	213,186	550,000	3,481,383	8,423,759	*f*55,409	161,790
1894....	14,901	109,936	....	.....	107,327	140,659	229	515	113,874	450,325	3,495,599	8,447,329	52,404	147,861

Year.	Copper, Fine. (*g*)		Feldspar and Quartz.		Glass and Glassware.	Gold, Kilos. (*i*)		Graphite.		Grindstones.		Gypsum (Exports).	
1890....	2,729	$902,050	817	$3,500	$537,130	1,497	$1,149,776	159	$5,209	4,432	$42,340	205,544	$194,033
1891....	4,324	1,160,760	622	3,425	.....	1,595	930,614	236	1,560	4,064	42,587	184,705	206,251
1892....	3,215	826,849	159	525	.....	1,566	907,601	151	3,763	4,793	51,187	218,679	241,127
1893....	3,679	875,865	*h*612	5,025	.....	1,692	976,603	20	.....	4,173	38,379	195,668	196,150
1894....	3,847	805,760	.....	.....	.....	1,648	954,451	350	.....	3,408	32,717	203,300	202,031

Year.	Iron Ore.		Chrome Iron Ore.		Pyrites.		Iron, Pig. (*j*)		Iron Manufactures.	Lead (in Ore).	
1890	69,429	$155,380	....	....	44,671	$123,068	19,751	$331,688	(*j*)	51	$5,085
1891	62,594	142,005	....	....	59,312	203,193	21,674	368,901	21,680	267	25,607
1892	93,667	263,866	....	....	54,223	179,310	38,504	637,421	....	*k*802	72,505
1893	*j*113,128	298,018	....	....	53,108	175,626	50,754	790,283	....	*k*968	78,996
1894	*j*99,782	226,611	2,009	$36,946	36,765	121,581	45,327	646,447	....	*k*2,628	158,262

Year.	Lime, Bushels. (*b*)		Limestone for Flux.		Manganese Ore.		Mica, Kilos.		Nickel, Kilos.		Mineral Paint. (*n*)	
1890	2,501,079	$412,308	16,768	$18,361	1,205	$32,550	350,436	$68,074	652,610	$933,232	249	$5.125
1891	1,829,894	251,215	10,323	11,547	213	6,694	....	71,510	2,103,012	2,775,976	816	17,750
1892	2,260,640	411,270	20,836	21,492	104	10,250	....	*l*104,745	*m*1,094,837	1,399,956	354	5,800
1893	6,750,000	900,000	25,217	27,519	193	14,578	....	*l*69,622	*m*1,806,669	2,071,151	971	17,710
1894	....	*c*900,000	31,843	34,347	67	4,180	....	*l*50,000	2,225,976	2,061,120	1,048	11,120

Year.	Crude Petroleum, Barrels. (*o*)		Phosphate.		Fertilizers.		Platinum.	Precious Stones.	Roofing Cement.		Sand and Gravel (Exports).		Molding Sand.	
1890	765,029	$902,734	28,814	$361,045	1,092	$31,889	$4,500	$700	1,063	$6,502	310,488	$65,518	290	$1,410
1891	755,298	1,004,546	21,405	241,603	......	....	10,000	1,000	817	4,810	221,165	59,501	209	1,000
1892	779,753	982,489	10,825	157,424	......	....	3,500	1,000	726	12,000	270,235	85,329	313	1,380
1893	798,406	834,334	7,437	70,942	......	....	1,800	1,500	863	5,441	298,569	121,795	*c*4,291	9,460
1894	829,104	835,322	6,613	43,940	......	....	1,000	1,500	513	1,978	294,523	86,940	*c*2,789	6,148

Year.	Salt.		Silver, Kilos. (*p*)		Slate.		Soapstone		Sulphuric Acid.	Terra Alba.		Terra Cotta.	Various Products.	Whiting.	
1890	39,704	$198,897	9,367	$420,662	5,779	$100,250	832	$1,239	$700	5,044	$145,235	$90,000	$995,667	454	$500
1891	40,854	161,179	9,713	406,233	......	....	522	863	....	.....	....	113,103	694,441	....	.....
1892	41,267	162,041	9,661	269,489	4,699	69,070	....	......	....	.....	....	97,239	*r*752,610	....	.....
1893	56,539	195,926	13,000	321,423	6,452	90,825	640	1,920	....	.....	....	*q*55,704	382,144	....	.....
1894	51,890	170,687	20,202	409,239	......	75,550	831	1,640	....	.....	....	*q*65,600	345,372	500	750

(*a*) From reports compiled by the Geological Survey of Canada, kindly furnished by Mr. Elfric Drew Ingall.
(*b*) Incomplete. (*c*) Estimated. (*d*) Metric tons.
(*e*) Contains in 1893, 16,000 M., value $191,000; sewer-pipe value $194,462; in 1894, tiles value $200,000, sewer-pipe $250,325; tiles estimated in 1893 and 1894.
(*f*) The entire production of Nova Scotia.
(*g*) Copper contents of ore, matte, etc., values per lb.: 1890, 15c.; 1891, 13c.; 1892, 11⅔c.; 1893, 10⅘c.; 1894, 9½c.
(*h*) Includes quartz, 91 metric tons, value $500.
(*i*) Nova Scotia and Ontario gold is computed at $19.50 per oz., except in 1890, when no Ontario gold was produced, and 1891 Ontario gold at $20. British Columbia gold, and that of the Northwestern Territories, including the Yukon district, at $17; Quebec gold at $18, except in 1891 at $20 per oz.
(*j*) Native iron ore converted into pig-iron in 1890, 51,985 metric tons, value $117,880; in 1891, 55,278 metric tons, value $130,955; in 1892, 87,950 metric tons, value $250,966; in 1893, 112,539 metric tons; in 1894, 98,766 metric tons.
(*k*) Lead contents of ores in 1890 at 4½c. per lb., in 1891 at 4$\frac{7}{20}$c. per lb., in 1892 at 4$\frac{1}{10}$c. per lb., in 1893 at 3$\frac{7}{10}$c. per lb., and in 1894 at 3¼c. per lb.
(*l*) Exports, plus quantity sold to Canadian electrical and stove manufacturers.
(*m*) In 1892, exports of fine nickel in matte, ore, etc., valued at 58c. per lb. (In matte at Sudbury the values of the metals would be nearer 6c. for copper and 18⅔c. for nickel.) Total value at Sudbury of the matte shipped during 1892, $450,560. In 1893 at 52c. and in 1894 at 42c. per lb., which represent the final market value of the nickel. In matte its value at the mine would be about 13c.
(*n*) Comprises ochre; in 1890, 1891, and 1892, ochre alone.
(*o*) Calculated from the inspection returns at 100 gallons crude to 38 gallons refined oil. The value of the crude was in 1890, $1.18 per bbl. of 35 imperial gallons; in 1891, $1.33; in 1892, $1.26; in 1893, $1.04½; in 1894, $1 00¾ per bbl. 1 barrel refined = 42 imperial gallons.
(*p*) Silver contents of ore; values for production and exports: 1890, $1.05 per oz.; 1891, $0.98; 1892, $0.86⅔; 1893, 0.76\frac{9}{10}$; 1894, $0.63.
(*q*) In 1893 includes porous fireproof terra cotta; in 1894 includes porous fireproof terra cotta and other structural and ornamental forms.
(*r*) 1892 not including natural gas, value $150,000; 1893 includes 50,335 metric tons, value $470 (zinc contents of ore at 4c. per lb.); natural gas, $376,233; and 863 tons roofing cement, worth $5441, and 512 tons roofing cement, valued at $1978; 1894 includes 163 metric tons lithographic stone, value $30,000; also natural gas, value $313,754, being the gross amount received through sale.

Estimating the value of certain other products not enumerated, the total value of the output of the mines and quarries of the Dominion in 1894 was $20,769,991, against $21,522,506 in 1893. The decrease of $752,515 in 1894 was rather in values than quantities.

The mineral imports and exports as reported officially are given in the following tables:

MINERAL IMPORTS OF THE DOMINION OF CANADA. (*a*) (IN METRIC TONS.)

Year.	Brass. (*u*)	Cement	Clays.	Bricks and Tiles.	Earthenware and China.	Coal, Anthracite. (*b*)		Coal and Coke.		Copper. (*u*)	Glass.	Gold and Silver. (*u*)
1890	$563,245	$328,110	$61,848	$105,818	$695,206	1,089,834	$4,595,727	1,359,826	$3,692,121	$484,189	$1,230,585	$256,164
1891	603,043	313,767	56,766	120,667	634,907	1,269,213	5,224,452	1,539,934	4,274,631	563,522	1,247,692	244,042
1892	537,105	287,729	82,619	81,495	748,810	1,341,824	5,640,346	1,579,237	4,333,490	431,427	1,257,858	261,471
1893	514,171	327,148	70,565	89,750	709,737	1,361,277	6,355,285	1,591,711	4,168,515	475,714	1,219,543	298,439
1894	455,852	289,971	70,731	138,763	705,047	1,388,468	6,354,040	1,405,656	3,592,267	286,814	1,170,974	208,474

Year.	Coin and Bullion.	Gunpowder	Iron and Steel. (*u*)	Lead. (*u*)	Metal Manufactures.	Mineral Oils, Gallons.		Precious Stones and Jewelry.	Salt.		Stone and Marble. (*u*)	Tin. (*u*)
1890	$1,083,011	$127,578	$13,524,899	$380,242	$352,859	5,244,108	$546,051	$560,961	78,755	$309,840	$385,468	$1,289,756
1891	1,811,170	110,515	13,826,492	325,455	351,809	5,321,524	550,925	425,012	95,541	380,550	392,941	1,206,918
1892	1,818,530	136,171	12,625,422	317,142	373,819	5,793,636	494,004	344,827	100,008	380,958	276,005	1,594,205
1893	6,534,200	143,028	13,199,523	288,636	353,225	6,249,946	473,279	366,623	96,595	361,300	231,497	1,274,866
1894	.....	124,888	11,602,080	201,799	1,136,103	7,752,257	622,256	428,840	.....	.....	227,356	1,310,810

MINERAL EXPORTS OF DOMESTIC PRODUCE FROM THE DOMINION OF CANADA. (*a*) (IN METRIC TONS.)

Year.	Whiting.	Zinc.	Various Metals.	Various Minerals.	Asbestos.	Agric. Impl.	Barytes.	Brick. Thous'ds.		Cement.	Cinders.	Clay Mfes of.	Coal.	
1890	$27,421	$92,530	$197,355	$103,118	5,954	$444,159	$367,199	[e]	$850	915	$5,168	$322	$6,902	.....	648,967	$2,447,936
1891	27,504	105,023	191,730	88,962	6,370	513,909	252,680	8	1,190	128	858	1,746	$50	5,884	756,106	2,916,465
1892	26,867	127,302	199,777	107,103	6,637	514,412	402,778	.	.....	504	2,750	1,495	5,451	120	857,403	3,195,467
1893	25,563	124,360	196,783	100,332	5,351	396,718	462,253	.	.....	3,625	24,560	894	4,118	113	823,934	3,114,558
1894	26,649	96,756	97,180	245,409	5,651	339,706	465,682	.	.....	4,502	33,013	1,268	2,941	67	903,557	3,321,565

Year.	Coke.		Charcoal.	Coin and Bullion.	Copper Ore.		Copper Matte, Regulus, etc.		Copper, Fine.		Explosives.	Glass and Glassware.	Grindstones	Gypsum, Crude.		Iron and Steel, M'f's of
															$	$
1890	317	$1,050	$31,634	.....	1,276	$111,086	217	$23,924	816	$109,327	9	$19,219	$9,668	$21,673	158,858	193,879	294,928
1891	6	21	61,323	$129,324	2,793	269,169	780	64,719	1,414	171,308	61	66,153	5,521	24,568	156,486	184,977	257,461
1892	...	.....	46,817	306,447	308	30,755	...	.....	1,723	185,848	75	61,763	1,964	23,465	161,949	194,304	243,857
1893	...	.....	48,700	309,459	64	3,850	326	391,969	.....	.....	58	56,764	4,648	25,702	160,108	178,979	316,454
1894	2	10	33,191	310,006	(*c*)	.....	(*c*)	.....	(*c*)	.....	35	29,050	4,433	19,330	147,337	160,082	295,924

Year.	Lime.	Metals other than Iron and Steel, M'f res of.	Mica, Crude, and Cut.		Mica, Ground.	Mineral Oils. Gallons.		Nickel, in Ore		Antimony.		Ores.				
												Gold, Quartz, etc.	Iron.		Lead.	
1890	$175,184	$36,639	16	$24,479	$2,453	358,804	$15,812	.....	.....	56	$1,520	$657,022	12,529	$31,366	4	$2,000
1891	153,265	42,633	74	19,666	2,646	436,516	18,726	2,428	$240,499	..	.....	554,126	13,288	32,582	....	.....
1892	124,152	17,495	618	63,708	4,758	440,906	18,217	6,911	617,639	4	60	316,177	6,992	36,935	27	5,200
1893	106,105	24,133	292	92,529	4,371	178,101	6,814	4,048	427,557	..	.....	247,868	7,086	26,114	68	2,329
1894	71,171	24,169	155	26,553	.....	68,740	2,722	3,815	808,790	..	.....	318,258	1,678	9,026	1,503	65,337

Year.	Ores.				Phosphates.	Fertilizers.	Plumbago.		Salt.		Sand and Gravel.	Slate.		Stone.	Tin. M'fr's.
	Manganese.		Silver.												
1890	1,623	$37,697	216	$201,615	26,957	$401,827	$4,291	46	$1,905	154	$1,522	299,052	$60,359	22	$3,268	$91,998	$6,410
1891	798	16,218	280	238,367	22,006	422,200	5,128	...	163	145	1,429	294,037	63,326	...	.....	63,398	12,615
1892	150	6,106	295	193,441	15,643	380,462	8,763	58	438	83	763	208,445	60,285	57	1,507	60,209	5,115
1893	132	13,596	379	65,406	10,786	132,475	7,706	227	*e*3,586	102	955	303,031	117,760	131	2,654	44,733	6,160
1894	45	4,353	*d*20	423,707	4,488	40,400	31,413	...	10	127	1,280	274,664	96,453	67	1,390	46,833	6,151

(*a*) From the tables of the *Trade and Navigation of the Dominion of Canada.* The import figures are for home consumption only. The exports are those of domestic produce. Fiscal year ends June 30.
(*b*) Including anthracite coal dust.
(*c*) In 1894 was exported copper contents of ores, matte and regulus. and fine copper, 541 tons; value $88,352.
(*d*) Silver contents of ores. (*e*) Also exported in 1893, plumbago, manufactures, value $198.

British Columbia.—The resources of this colony in coal and the precious metals are well known, and their exploitation is extending steadily. So far as yet tested the coal of British Columbia is the best found on the Pacific Coast, and its mines furnish an important part of the supply of California. Gold and silver mining is making much progress, in spite of the drawbacks resulting from the low price of silver. As might be expected from its geographical position and natural trade relations, the gold and silver mines have been thus far chiefly worked by miners from the United States and are owned on this side of the boundary line.

Manitoba and the Northwestern Territory.—The only mineral industry thus far developed is the mining of coal. A considerable quantity is produced to supply the local demand.

New Brunswick.—This colony has deposits of manganese ore, coal and other minerals, and has also beds of granite and other valuable building stones, while the lime industry is an important one. Mining, however, is not of so great importance as in the adjoining colony of Nova Scotia. Gold has been found in several localities in New Brunswick, but never worked with success.

Nova Scotia.—The chief mineral resources are coal and gold, though manganese ore and other minerals are found, and iron ore of excellent quality supply the only blast furnaces successfully worked in Canada. The following figures for the mineral production have been furnished us by Mr. E. Gilpin, Jr., of the Mines Department.

MINERAL PRODUCTION OF NOVA SCOTIA. (IN METRIC TONS).

Year.	Brick, Thousands.		Coal.		Coke.		Copper.		Gold, Kilos.		Grindstones.	
1890....	8,400	$55,360	2,015,427	$3,571,202	51.270	$166,298	900	.....	757	$474,990	771	$8,536
1891....	8,825	54,775	2,077,878	3,579,586	51,775	175,592	.....	.....	620	451.503	1,796	19,800
1892....	13,761	89,446	1,973,554	3,399,865	50,914	160.249	22	$100	622	389,965	2,662	27,610
1893....	.....	85,000	1,709,636	2,625,000	52,438	154,836	1,270	.....	436	395,070	.....	6,971
1894....	.....	.....	2,235,438	3,487,000	60,592	181,700	.....	.....	621	560,000	.....	6,681

Year.	Gypsum.		Iron Ore.		Iron, Pig.		Building Stone, Cubic Yards.		Lime, Bushels.		Manganese.	
1890....	164,425	$154,972	44,630	$101,634	.....	.....	37,825	$92,211	217,944	$44,565	102	$2,499
1891....	146,874	153,955	48,659	112,745	.....	.....	(a)2,650	(a)28,037	.....	.....	(b)22	563
1892....	(a)147,271	157,463	70,980	194,581	.....	.....	(a)9,534	(a)25,460	70,775	20,540	(c)104	10,250
1893(d)..	(a)99,920	.....	67,906	.....	37,128	.....	.....	.....	.....	.....	103	8,625
1894....	(a)107,879	.....	84,848	.....	36,383	.....	.....	.....	.....	.....	24	.....

(a) These figures represent only about four-fifths of the total output. (b) Quantity exported.
(c) The increase in price is owing to the opening of Terry Cape mines and production of high grade ores.
(d) The official figures for 1893 are for nine months only, according to the provisions of the Acts of 1893, which require that all reports of the several departments of the government shall in 1893 be made up for a period of nine months ending September 30. From 1893, the fiscal year of the Province begins on the first day of October and ends on the 30th of September, and all reports must be made up for the year so beginning and ending.

Ontario.—Of all the Canadian colonies, Ontario has the most varied mineral industry. The production of petroleum and natural gas is large; but no coal has been found. Gold has been produced in considerable quantities in Western Ontario, though the mines there have been for the most part retarded in development by the difficulties encountered in working their complex ores. Recently large deposits of low-grade gold ores have been found in the Rainy Lake region along the international boundary, but their extent and value have not been fully determined as yet.

Perhaps the most important mineral resources of Ontario are found in the nickel mines of the Sudbury region, which are now furnishing the greater part of the world's supply of that metal and are capable of greatly increasing their output as the demand increases.

The following table shows the mineral production of Ontario:

MINERAL PRODUCTION OF ONTARIO.

	1893.		1894.	
	Quantity.	Value.	Quantity.	Value.
Apatite, metric tons	18	$200	.....	.....
Brick, common, number	162,350,000	932,000	131,500,000	$690,000
Pressed, number	20,208,000	192,672	22,460,000	198,510
Fancy pressed, number	1,373,700	20,911	2,896,000	34,160
Building stone	.....	721,000	.....	.....
Dimension stone, cubic feet	.....	.....	1,340,000	360,470
Heads and sills, cubic feet	.....	.....	47,070	15,900
Coursing stone, square yards	.....	.....	22,000	36,000
Rubble, etc., cubic yards	.....	.....	223,000	142,000
Cement, natural rock, barrels	74,353	63,567	55,323	48,774
Portland, barrels	31,924	68,848	30,580	61,060
Cobalt, metric tons	17	9,400	2.94	3,500
Copper, metric tons	1,298	115,200	2,493	195,750
Draining tile, number	17,286,000	190,450	25,000,000	280,000
Gypsum, metric tons	(*a*)2,683	22,163	2,951	9,760
Calined plaster, etc., metric tons	.....	.....	1,308	22,697
Gold, kilos	53	30,120	62,907	32,776
Lime, bushels	2,700,000	364,000	2,150,000	280,000
Mica, metric tons	18	1,600	.....	.....
Nickel, metric tons	1,490	454,702	2,332	612,724
Natural gas, thousand cubic feet	1,962,000	190,705	1,653,500	204,179
Petroleum, barrels	1,045,000	1,100,000	997,496	.....
Illuminating oil, barrels	.....	.....	341,654	1,337,040
Lubricating oil, barrels	.....	.....	90,885	242,688
All other oils, barrels	.....	.....	253,146	343,416
Paraffin wax, metric tons	.....	.....	124.9	152,467
Fuel products	.....	.....	.....	71,326
Pottery	.....	115,000	.....	134,000
Roofing tile, number	.....	(*b*)5,790	100,000	1,200
Terra cotta	.....	.....	.....	52,360
Salt, metric tons	43,546	150,000	31,946	115,551
Sand and gravel, cubic yards	.....	.....	733,500	203,450
Sewer pipe	.....	200,000	.....	207,000
Silver ore, metric tons	454	.....	.....	.....

(*a*) Gypsum and products. (*b*) Including terra cotta.

Quebec.—The varied resources of Quebec, including copper, asbestos, mica, phosphates and other valuable minerals, are well known and have been worked to a considerable extent. The asbestos mines furnish a considerable supply. The phosphate industry has declined from various causes, and some of the deposits appear to be exhausted. The iron ores produced are the bog ores of the eastern counties; the great deposits of titanic iron ores have not been touched. The following tables show the production of the province.

MINERAL PRODUCTION OF QUEBEC IN 1893. (*a*) (IN METRIC TONS.)

	1893.	1894.		1893.	1894.
Asbestos	6,576	2,693	Iron, magnetic ore	1,575	.....
Copper, low grade ore	58,935	38,168	Lead	91	63
Copper, high grade ore	45	.....	Mica, rough and dressed	1,056	1,175
Feldspar	907	533	Ocher	862	979
Gold, kilos	11,056	239	Phosphates	10,342	2,978
Granite, cu. ft	100,000	.....	Serpentine	272	.....
Graphite	296	317	Slate	4,341	3,138
Iron, bog ore	26,967	26,005			

(*a*) From the report of the *Commissioner of Crown Lands* of the Province of Quebec. Fiscal years ending 30th of June.

CHILE.

THE mineral production of Chile is chiefly exported in various forms. Of the metallic output copper forms by far the most important part, and the production of Chile at one time constituted a very considerable portion of the world's supply, though its comparative value has much diminished.

The chief non-metallic product is nitrate of soda, which is obtained from the great beds of the northern part of the country. These have long been extensively worked, and their exploitation is extending, the government having sold during 1894 some extensive tracts of nitrate lands.

MINERAL EXPORTS OF CHILE. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Borax.		Calcium Borate.		Coal.		Copper Bars.		Copper Matte. (*b*)	
1890	37.0	$5,161	3,536.1	$176,809	194,676	$1,674,394	24,287.8	$8,543,469	1,420.0	$220,619
1891	815.0	106,969	6,463.0	318,080	.....	2,053,988	17,464.0	4,872,964	2,838.0	338,558
1892	.....	.....	.....	.....	215,140	1,535,029	19,144	5,076,922	.....	.....
1893	.....	.....	.....	.....	209,711	1,677,904	19,328	4,844,353	.....	.....

Year.	Copper Matte, Argentiferous. (*c*)		Copper Ores (*d*)		Copper, Silver Ores. (*e*)		Gold, Kilos.		Gold Ores.		Gold and Silver Ores.	
1890	2,499.1	$879,977	1,175.9	$68,794	462.7	$42,768	665.17	$531,945	1,818.2	$418,200	1,230.90	$275,555
1891	1,666.0	681,776	5,860.0	203,403	47.0	4,694	599.00	479,789	288.0	69,142	87.00	65,343
1892	*f*1,531.3	301,239	.....	.....	92.5	11,197	854.55	683,638	97.0	19,010	*f*2.73	961
1893	.....	.....	.....	.....	.....	.....	954.54	602,761	.....	.....	.....	.....

Year.	Iodine.		Manganese Ores.		Nitrate.		Silver Bars, Kilos.		Silver, Old Plate, Kilos.	
1890	419.74	$4,197,420	50,997.5	$509,975	1,025,617.1	$36,925,414	101,925.20	$4,335,219	.....	$382,109
1891	424.02	4,240,190	35,610.4	356,106	891,727.1	32,418,491	115,630.38	4,506,771	.....	250,512
1892	513.85	5,138,460	51,685.1	516,851	797,827	31,785,060	138,845.38	5,017,390	1,147.88	311,535
1893	595.34	5,953,380	36,740.9	367,410	943,570	39,211,913	140,368.60	4,418,072	.....	.....

Year.	Silver Lead Ores.		Silver Ores.		Silver Sulphide Ores.		MINERAL IMPORTS OF CHILE	
							Coal.	Iron.
1890	.....	.....	1,676	$926,375	.....	.....	$3,174,676	$573,988
1891	126.0	$74,338	611	174,289	132.0	$166,023	4,113,770	512,668
1892	.....	.....	915	418,077	.....	.....	3,078,044	658,586
1893	.....	.....	330	206,996	.....	.....	.....	.....

(*a*) From the *Boletin de la Sociedad Nacional de Mineria*, p. 46, 1892, from *Estadistica y Geografia de la Republica de Chile*, Santiago, 1894, and from "*Deutsches Handels Archiv*," 1894. (*b*) 50% copper. (*c*) 50% copper; 0.53% silver. (*d*) 20% copper. (*e*) 15% copper; 0.63% silver. (*f*) Copper, silver, and gold matte, 188.1 tons, $40,037, and copper, silver, and gold ore, 219.1 tons, $26,356, were also exported during 1892.

CHINA.

But few statistics can be obtained for this great country of which there is still, in spite of the commercial developments of recent years, so little really known. The tables below give the figures.

China is known to have large resources in coal and iron deposits, which are as yet hardly touched. It possesses also mines of silver, lead, copper and other metals and is believed to be to some extent a producer of gold; but on these points no certain information can be procured.

There is a general belief that the settlement of the recent war with Japan will result in important developments of the mineral and other industries of China; but upon this point it is not yet possible to make any definite predictions.

MINERAL IMPORTS OF CHINA. (*a*) (IN METRIC TONS.)

Year.	Coal.	Copper, Sheets.	Copper, Old.	Gypsum.	Iron, Bar, Hoop.	Iron, Nail-Rod.	Iron, Manufactured.	Iron, Pig.	Iron, Old.	Iron, Wire.
1889.....	18,008	906	1,068	10,367	3,928	13,524	3,695	240	11,860	502
1890.....	6,165	574	970	11,000	4,147	16,080	4,180	588	17,979	1,022
1891.....	6,267	750	926	7,658	5,041	18,120	5,290	408	22,656	1,110
1892.....	15,373	822	834	9,326	4,431	17,316	4,400	316	19,660	1,308
1893.....	11,430	610	540	9,858	3,855	15,270	3,867	396	16,316	1,325

Year.	Kerosene, 1000 Gals.	Lead, Pig.	Lead, White.	Lead, Yellow.	Quicksilver.	Salt.	Steel.	Tin.	Tin, Slabs.	Tin, Plates.	Yellow Metal.
1889.....	8,835	8,076	.....	.....	60	2,628	1,278	.....	1,991	165	455
1890.....	15,384	7,719	8	7	58	3,729	1,189	.....	2,366	154	537
1891.....	23,644	8,334	9	11	98	9,570	1,660	29	2,209	113	606
1892.....	23,286	8,604	13	12	154	8,976	1,557	73	2,100	187	602
1893.....	34,764	8,520	8	9	107	12,798	2,015	17	2,616	258	940

MINERAL EXPORTS OF CHINA. (*a*) (IN METRIC TONS.)

Year.	Alum, White.	Coal.	Copper, Cash, Strings.	Copper, Tribute.	Gypsum.	Ironware.	Steel.	Tin.
1889.....	3,426	61,235	16,194	.....	8,200	2,100	.....	60
1890.....	3,199	111,016	2,440	.....	8,046	2,836	305	65
1891.....	4,005	145,440	26,800	927	6,894	2,841	240	126
1892.....	4,760	140,967	6,091	618	8,670	2,469	207	73
1893.....	5,511	131,773	464	618	8,956	2,812	164	16

MINERAL IMPORTS OF KOREA. (*a*) (IN METRIC TONS.)

Year.	Brass Metal, Etc.	Coal.	Copper, Pigs and Slabs.	Copper, Nails, Wire.	Copper Ore.	Iron, Nail-Rod.	Iron, Bar, Hoop.	Iron, Old.	Iron, Nails.	Kerosene, Gallons.
1886.....	.....	.....	46	3	.....	20	6	91	10	70,932
1887.....	.....	147	137	13	.....	75	41	117	11	160,824
1888.....	5	48	344	5	.....	18	60	276	25	204,075
1889.....	198	646	1,177	16	.....	3	46	213	30	398,430
1890.....	54	401	346	18	.....	72	176	387	65	415,325
1891.....	55	1,291	1,148	37	.....	9	221	296	42	540,390
1892.....	115	1,373	653	18	198	31	192	260	92	724,563
1893.....	199	791	1,064	13	215	62	284	451	90	936,000

Year.	Lead.	Metals, Manufactured.	Nickel.	Quicksilver.	Salt.	Spelter, Zinc.	Steel.	Tin, Slabs.	Tin Compounds.	Tin, Plates.	White Metal.
1886.....	.....	12		1.08	1,033	18	.....	30	.....	1	6
1887.....	.....	34	.....	2.70	5,393	13	.....	27	9	17	12
1888.....	45	43	.....	3.78	280	200	.....	19	10	15	23
1889.....	170	63	.....	2.28	479	842	8	24	9	24	15
1890.....	.....	180	.....	4.32	146	27	89	63	32	38	28
1891.....	240	360	.....	3.62	1,305	828	86	49	28	31	28
1892.....	46	210	0.96	2.46	1,625	475	45	67	31	17	16
1893.....	142	150	1.14	3.6	2,652	1,116	71	75	17	48	24

MINERAL IMPORTS, EXPORTS AND RE-EXPORTS OF AMOY. (*a*) (IN METRIC TONS.)

	IMPORTS.						EXPORTS.			RE-EXPORTS.	
Year.	Iron, Bar, Nail-Rod.	Iron, Old.	Kerosene, Gallons.	Lead, Pig.	Quicksilver.	Tin, Slabs.	Bricks and Tiles, Pieces.	Chinaware.	Iron, Pans, Ironware.	Lead, Pig.	Tin, Slabs.
1886....	108	614	148,592	172	19	426	665,114	1,396	600	290	162
1887....	133	565	199,180	310	17	403	4,105,510	1,664	724	231	252
1888....	91	474	156,360	156	18	616	4,335,807	1,506	740	183	206
1889....	126	600	324,300	288	17	485	3,615,517	1,252	562	130	313
1890....	55	395	906,900	174	22	393	5,434,172	906	448	168	270
1891....	78	546	1,181,920	174	21	395	3,131,719	1,120	499	118	240
1892....	55	512	1,895,030	266	18	462	2,855,712	1,243	529	180	174
1893....	54	778	1,533,290	200	13	435	4,357,208	1,070	639	150	156

(*a*) From special tables, statistical series, *Imperial Maritime Customs*, China.

MINERAL IMPORTS OF SHANGHAI. (*a*) (IN METRIC TONS.)

Year.	Coal. (*c*)	Copper	Iron.	Lead.		Kerosene. (*b*)	Quicksilver.	Steel.	Tin.		Yellow Metal and Nails.	Zinc in Sheets.
				Pig.	Sheets.				Slabs.	Plates.		
	Tons.	Tons.	Tons.	Tons.	Tons.	Cases.	Kilos.	Tons.	Tons.	Tons.	Tons.	Tons.
1889....	.....	1,747	49,627	6,660	147	1,506,532	58,834	1,058	2,124	480	216	106
1890....	.....	604	40,960	6,167	67	1,820,449	62,315	1,669	2,237	520	326	287
1891....	.....	1,631	73,688	4,516	51	2,921,169	52,090	1,740	2,198	614	260	179
1892....	.....	1,571	59,468	5,366	52	2,092,567	90,024	1,265	2,440	725	53	283
1893....	396,947	1,577	48,386	4,799	49	2,559,500	31,460	929	2,170	479	263	267
1894....	420,556	.....	.....	.....	.....	3,403,923	.....	.....	.....	.....	.....	.....

(*a*) From Alex. Bielfeld's reports, Shanghai. Tons converted from piculs. (1 picul = 0.6 metric ton.) (*b*) 1 case holds 10 gallons. (*c*) From Wheelock & Co.'s report, Shanghai.

IMPORTS AND EXPORTS OF GOLD AND SILVER OF CHINA. (*a*)
(1 half-tael = $1.)

IMPORTS.			EXPORTS.		
Year.	Gold.	Silver.	Year.	Gold.	Silver.
1893.....	$5,142,814	$49,515,467	1893.....	$12,643,783	$37,612,051

(*a*) From statistical series, 1893, *Imperial Maritime Customs*, China

EXPORTS OF GOLD FROM COREA.
(1 half-tael = $1.)

EXPORTS.		EXPORTS.	
Year.	Gold.	Year.	Gold.
1892.....	$852,751	1893.....	$918,659

FRANCE.

THE mineral production of France constitutes an important portion of the national industry, and in the present volume, through the kindness of the Ministry of Public Works of that country, we are able to present very complete tables showing the output of the various minerals produced from 1873 to 1893, inclusive, and in addition that of some leading articles for the year 1894. The statistics of the industry in France are made up with much care, but their correction and arrangement requires so much time that the full figures for last year are not yet available.

The two more important articles of production are mineral fuel and iron ore. Although the mining of coal has shown a considerable increase during the last ten years, the supply is not sufficient for home use, and imports to a considerable amount are recorded. The coal production last year, as will be seen from the tables, amounted to 27,459,137 tons, including lignite, showing an increase of 1,800,000 tons over the preceding year. During the period shown in the table, while there has been a gain of over 10,000,000 tons in the total output, the variations have been made in a somewhat remarkable way. From 1873 to 1879, for instance, the yearly output was about 16,500,000 tons, with but small changes; in 1880 it rose to 18,800,000 tons and in 1882 had increased to 20,000,000 tons; from that year to 1887 it oscillated slightly between 19,000,000 and 20,000,000 tons. In 1888 there was another sharp increase to 22,170,000 tons, followed by a further gain to 23,850,000 tons the next year. For 1890 the amount of the total was 25,600,000 tons, and there were but very slight changes for four years; but 1894 was again marked by a sharp increase, as noted above. The production of lignite, which has never risen to 600,000 tons, has decreased slightly and was last year 50,000 tons less than in 1873.

The coal industry of France, in recent years, has suffered very much from strikes and labor troubles, and the mine owners complain that the rate of wages, especially in the Pas-de-Calais and the Bassin-du-Nord, the two more important coal districts, has been forced up to a point so high that it is very difficult for them to work at a profit in competition with others. In 1894 trade was perhaps less disturbed by strikes than in several years before, although the long lockout at the Carmaux mines has become almost a landmark in the history of labor troubles.

The tables of mineral production are as follows:

MINERAL PRODUCTION OF FRANCE. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Alunite.		Antimony Ore.		Bauxite.		Bituminous Substances. (*b*)		Copper Ore.		Manganese Ore	
1873..	.....	.....	79	$4,596	650	$9,750	156,107	$196,990	2,432	36,426	12,378	$160,781
1874..	1,219	$43,884	177	8,273	1,366	16,392	137,702	198,667	6,008	55,166	11,392	110,675
1875..	1,219	43,884	223	11,296	1,450	17,400	140,696	188,963	8,698	94,589	9,016	93,237
1876..	553	19,643	395	14,981	2,000	38,000	140,000	185,000	7,724	69,929	4,871	44,033
1877..	910	32,000	467	18,299	3,600	66,500	140,000	185,000	6,306	64,314	7,174	59,126
1878..	1,104	38,916	753	17,066	4,160	78,400	140,000	185,000	2,668	31,161	9,382	61,165
1879..	227	8,383	642	24,771	6,800	127,000	138,431	180,476	548	14,001	5,968	65,356
1880..	1,223	48,952	214	48,688	5,685	100,850	144,622	204,549	8,649	29,887	9,652	106,543
1881..	1,036	41,453	632	61,345	12,060	122,300	179,257	240,175	8,170	47,274	13,708	98,466
1882..	709	26,241	1,073	38,690	10,030	144,135	188,064	237,609	7,136	41,727	7,538	48,028
1883..	288	11,403	1,059	36,152	15,214	259,614	147,337	227,522	16,475	138,121	6,573	39,557
1884..	221	8,840	657	18,809	23,575	313,119	202,307	280,819	1,289	22,541	4,535	32,540
1885..	.....	.....	536	15,330	19,108	251,879	198,385	258,312	433	9,170	3,424	20,647
1886..	.....	.....	247	8,892	24,772	226,825	189,742	253,496	167	4,067	7,676	53,099
1887..	.....	.....	341	8,745	20,515	164,942	179,207	227,274	11	732	12,124	50,501
1888..	.....	.....	789	21,953	19,160	188,730	191,718	263,865	6	288	11,048	60,757
1889..	.....	.....	1,100	36,000	18,670	178,200	200,500	285,000	.....	.....	10,000	59,000
1890..	.....	.....	4,962	161,259	18,670	178,200	233,344	311,847	15	541	15,984	89,517
1891..	.....	.....	5,316	133,518	22,260	190,750	260,626	338,889	16	1,625	15,343	90,316
1892..	.....	.....	5,100	135,200	23,298	196,524	224,311	335,600	251	6,078	32,406	205,074
1893..	253	12,650	7,200	130,000	33,923	261,248	222,000	322,400	.....	.....	38,080	290,073
1894*d*.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Year.	Iron Ore.		Iron Pyrites.		Mineral Fuel.					
					Coal.		Lignite.		Peat.	
1873.....	3,051,124	$3,575,735	161,659	$616,299	16,974,236	$56,897,728	505,105	$1,175,831	324,092	$742,292
1874.....	2,516,548	2,974,558	148,768	535,990	16,428,626	54,708,610	479,287	1,174,868	323,198	733,095
1875.....	2,505,870	2,760,353	131,154	462,300	16,504,635	52,980,109	452,205	1,060,128	317,748	731,530
1876.....	2,393,340	2,674,505	139,269	456,013	16,601,448	52,990,000	500,000	1,100,000	333,110	874,603
1877.....	2,426,279	2,693,921	149,969	466,782	16,304,529	52,500,000	500,000	1,100,000	310,821	807,580
1878.....	2,469,953	2,542,996	131,046	403,183	16,560,916	50,000,000	500,000	1,100,000	296,241	730,186
1879.....	2,271,173	2,278,628	119,558	366,039	16,576,901	43,191,081	534,078	1,074,052	234,369	544,942
1880.....	2,874,263	2,981,711	132,288	419,059	18,804,767	48,255,039	556,797	1,082,989	248,122	550,967
1881.....	3,032,070	3,034,347	160,130	499,312	19,211,963	48,033,393	554,020	1,124,922	233,521	513,892
1882.....	3,467,251	3,368,389	180,339	548,140	20,046,796	49,842,166	556,908	1,082,334	216,633	501,282
1883.....	3,297,853	3,085,258	172,462	562,128	20,759,429	52,209,150	574,455	1,140,899	201,371	449,990
1884.....	2,976,948	2,565,609	165,583	541,624	19,527,120	48,296,857	496,394	1,066,251	196,691	420,378
1885.....	2,318,104	1,789,615	167,984	546,538	19,068,548	44,870,809	441,982	908,303	190,196	392,512
1886.....	2,285,648	1,643,806	184,884	539,140	19,454,127	43,663,329	455,767	886,511	175,311	378,164
1887.....	2,579,465	1,730,862	209,253	653,785	20,809,982	44,395,908	477,607	878,497	204,798	498,815
1888.....	2,841,757	1,894,216	203,814	614,381	22,172,029	45,825,779	430,865	773,299	159,658	351,227
1889.....	3,070,389	2,084,198	201,490	585,882	23,853,309	52,500,000	450,000	810,000	147,826	314,015
1890.....	3,471,718	2,477,079	229,661	655,922	25,591,545	61,365,211	491,573	917,290	157,701	342,317
1891.....	3,579,286	2,557,084	246,827	682,412	25,676,463	63,560,000	523,282	950,000	168,365	387,454
1892.....	3,706,748	2,516,168	230,480	572,256	25,697,223	64,038,800	481,468	896,600	168,445	394,251
1893.....	3,517,438	2,339,169	231,025	561,284	25,172,792	58,105,400	478,189	852,800	174,290	460,174
1894*d*.....	.....	.....	.....	.....	27,006,090	.....	453,047	.....	.....	.....

Year.	Lead-Silver Ore.		Salt.		Sulphur Ore. (*c*)		Tin Ore.	
1873.....	9,865	$619,919	627,176	$2,277,481	5,007	$13,651	1,279	$19,649
1874.....	10,445	670,055	656,159	2,625,508	4,318	11,614	3,848	57,446
1875.....	8,728	644,224	674,425	1,939,617	4,900	14,122	4,088	59,507
1876.....	9,330	602,931	577,493	1,850,000	5,280	14,720	8,018	108,279
1877.....	10,962	650,147	590,406	1,870,000	5,280	14,720	7,846	90,893
1878.....	10,070	513,264	570,984	1,760,000	160	416	7,550	55,471
1879.....	11,517	565,925	535,677	1,690,000	479	1,916	7,883	56,294
1880.....	13,990	645,876	693,054	1,900,500	932	3,727	12,139	77,084
1881.....	12,316	585,520	751,301	2,875,000	3,262	15,048	12,943	78,230
1882.....	13,462	656,704	766,626	3,529,167	649	2,597	9,372	61,535
1883.....	14,568	731,709	737,582	3,450,000	1,469	5,012	5,491	40,144
1884.....	11,657	552,119	805,949	3,650,000	6,376	19,649	3,120	17,936
1885	11,044	515,944	700,669	2,950,000	3,792	10,564	5,078	65,432
1886.....	14,672	611,697	663,443	2,363,458	4,776	19,102	11,103	136,079
1887.....	17,436	717,980	823,910	2,401,118	4,274	14,105	13,321	139,059
1888.....	19,419	842,796	631,548	2,397,599	3,065	10,114	20,702	296,554
1889.....	21,306	886,248	750,000	2,630,000	3,801	12,543	34,290	719,979
1890.....	25,787	1,057,679	842,529	3,483,264	4,285	13,535	47,540	950,619
1891.....	25,897	946,324	810,675	2,827,777	6,749	20,072	56,338	1,285,504
1892.....	21,656	673,164	973,752	3,353,390	7,231	20,972	69,236	1,134,400
1893.....	24,599	530,742	1,103,287	3,317,471	3,733	13,022	77,466	1,061,166
1894.....	.....	.....	.....	.....	.....	.....	.....	.....

(*a*) From *Annales du Commerce Exterieur* and *Statistique de l'Industrie Minérale.*
(*b*) Includes pure bitumen, bituminous schist, bituminous sand and asphaltic limestone; see details in special tables below.
(*c*) Sulphur and limestone impregnated with sulphur.
(*d*) From the Advance Report of the *Ministère des des Travaux Publics.*

PRODUCTION OF MINERAL OIL AND ASPHALT IN FRANCE. (*e*) (IN METRIC TONS.)

Year.	Mineral Oil.		Asphalt.		Year.	Mineral Oil.		Asphalt.		Year.	Mineral Oil.		Asphalt.	
1873..	5,813	$197,111	9,116	$97,577	1880..	4,322	$140,164	16,915	$160,766	1887..	6,154	$154,155	9,295	$79,293
1874..	6,016	221,745	8,483	83,606	1881..	5,553	165,475	17,227	153,989	1888..	6,274	148,986	7,881	64,128
1875..	4,861	169,911	12,006	113,688	1882..	5,053	149,788	18,556	154,302	1889..	7,557	196,327	12,223	106,600
1876..	7,348	241,815	14,612	140.733	1883..	3,527	95,102	19,556	172,713	1890..	7,906	182,513	11,199	97,527
1877..	8,343	264,786	11,752	114,612	1884..	6,636	172,461	14,679	126,051	1891..	9,926	239,460	15,070	132,407
1878..	6,907	196,914	12,680	120,631	1885..	6,677	165,905	11,706	106,820	1892..	8,008	191,160	14,690	138,702
1879..	6,137	180,085	11,706	115,688	1886..	7,723	199,266	11,112	100,367	1893..	8,710	189,580	13,608	103,165

(*e*) From *Statistiques de l'Industrie Minérale.*

In the metallurgical production of France iron and steel hold a place of first importance. The production of raw iron has not increased as much as might have been expected from the continually increasing demand, and a considerable amount is still imported. The wrought iron and steel and the finished products hold a high position in the metallurgical world, and the production of the Creusot and other noted steel works and of the great forges of the Rive-de-Gier have a wide reputation for excellence.

METALLURGICAL PRODUCTION OF FRANCE. (*f*) (IN METRIC TONS AND DOLLARS.)

Year.	Aluminum.		Antimony.		Copper.		Iron, Pig.		Iron, Wrought.		Steel.	
1873....	1.1	$21,360	.....	.....	9,721	$5,010,349	1,381,626	$38,057,734	892.549	$59,895,924	150,529	$12,700,765
1874....	1.4	28,600	.....	.....	11,264	5,691,769	1,415,897	33,744,556	858,380	49,117,649	208,787	14,878,092
1875....	0.9	18,000	.....	.....	11,478	5,547,628	1,448,572	31,278,305	869,676	46,021,134	256,393	16,244,588
1876....	0.9	18,000	71	$21,600	6,311	2,872,390	1,435,192	28,311,061	837,112	40,499,786	241,844	14,476,716
1877....	1.7	34,000	83	17,792	6,882	3,042,644	1,506,827	28,575,917	884,493	40,405,946	269,181	16,015,749
1878....	1.5	30,000	83	19,690	8,364	3,313,436	1,521,274	26,690,287	843,112	36,430,454	312,921	16,879,730
1879....	1.8	36,000	85	21,193	3,353	1,145,420	1,400,286	28,943,227	857,071	37,536,176	333,265	19,691,236
1880....	1.1	22,000	147	39,477	3,366	1,219,600	1,725,293	32,093,812	965,751	44,512,880	388,894	22,381,017
1881....	2.6	52,000	188	43,762	3,395	1,270,320	1,886,350	34,493,852	1,026,320	46,731,662	422,416	23,701,602
1882....	2.3	46,000	178	40,830	3,627	1,265,360	2,039,067	37,127,253	1,073,021	49,518,911	458,238	25,719,512
1883....	2.3	46,000	87	15,204	3,255	983,860	2,069,430	33,676,849	978,917	42,988,394	521,820	27,134,513
1884....	2.2	44,000	105	17,820	3,717	1,066,000	1,871,537	27,965,179	876,751	34,539,942	502,908	24,482,387
1885....	2.0	40,000	122	24,400	3,572	845,500	1,630,648	20,136,733	782,431	26,537,408	553,839	24,460,663
1886....	2.4	48,000	171	26,503	3.519	704,832	1,516,574	16,743,200	766,556	23,622,904	427,589	20,530,341
1887....	2.0	40,000	170	32,424	2,083	417,000	1,567,622	17,932,589	771,610	23,561,637	493,294	23,573,131
1888....	4.2	77,100	240	44,221	2,184	654,460	1,683,349	19,137,161	816,973	24,646,282	517,294	23,422,385
1889....	14.8	156,200	316	98,502	1,622	504,034	1,734,000	21,301,600	.....	.....	.....	.....
1890....	37.0	136,000	843	212,880	2,306	721,280	1,962,196	27,523,973	825,369	29,593,160	581,998	30,152,391
1891....	36.0	85,520	880	177,153	2,125	635,471	1,897,387	24,827,169	833,409	29,546,616	638,530	33,497,528
1892....	75.0	125,600	754	148,362	2,163	567,000	2,057,300	24,973,800	828,519	29,533,200	682,500	36,823,600
1893....	137.0	194,900	868	157,300	6,587	1,507,700	2,003,100	23,347,000	808,171	23,347,400	789,852	33,367,000
1894....	.....	.....	.....	.....	.....	.....	2,077,647	.....	808,657	.....	790,773	.....

Year.	Lead. (*g*)		Litharge.		Nickel.		Precious Metals. Gold, Kilos.		Precious Metals. Silver, Kilos.		Zinc.	
1873.....	7,000	$756,000	180	$17,480	25	$76,650	875	$600,000	32,591	$1,419,000	12,627	$1,749,118
1874.....	6,900	726,000	181	15,566	37	59,320	850	582,700	48,914	2,030,967	12,783	1,720,417
1875.....	6,700	691,400	192	16,512	5	7,340	959	657,520	49,735	1,957,400	13,739	1,908,303
1876.....	6,767	709,192	175	14,700	.....	.....	1,144	784,640	38,229	1,514,888	13,695	1,787,000
1877.....	8,278	816,317	48	4,697	.....	.....	1,125	771,872	37,906	1,479,418	11.881	1,132,060
1878.....	9,610	719,400	172	16,190	.....	.....	.....	.....	29,070	1,117,014	13,848	1,182,166
1879.....	8,947	677,308	144	9,216	30	60,000	.....	.....	36,626	1,374,026	14,794	1,249,112
1880.....	6,343	471,070	122	8,540	30	60,000	31	21,490	40,371	1,525,000	16,332	1,450,148
1881.....	7,000	514,000	97	7,000	80	135,000	39	26,780	54,718	2,056,000	18,509	1,486,000
1882.....	8,076	524,340	80	5,440	30	60,000	46	31,754	66,940	2,490,000	18,525	1,482,180
1883.....	7,770	449,900	57	3,477	30	60,000	105	72,180	48,491	1,786,337	15,915	1,260,483
1884.....	6,293	334,026	98	5,507	30	60,000	.....	.....	52,680	1,941,471	16,884	1,319,332
1885.....	4,806	252,220	110	6,215	30	36,000	.....	.....	50,828	1,728,152	15,108	1,150,902
1886.....	3,874	234,183	103	6,180	30	36,000	.....	.....	46,789	1,497,250	16,132	1,176,240
1887.....	5,939	356,400	83	5,146	30	36,000	.....	.....	54,314	1,740,000	16,712	1,212,953
1888.....	6,406	395,640	103	6,489	30	42,000	.....	.....	49,396	1,580,670	16,960	1,379,050
1889.....	5,305	320,960	67	4,422	330	342,000	400	.....	80,942	2,590,144	17,982	1,693,439
1890.....	4,544	307,731	43	2,838	330	333,000	200	128,000	71,117	2,275,774	19,372	1,977,211
1891.....	6,680	417,116	63	3,906	330	336,400	220	140,800	71,303	2,281,696	20,596	2,070,333
1892.....	8,776	510,478	49	2,619	1,244	1,236,400	210	144,075	103,247	2,994,163	20,609	1,993,956
1893.....	8,119	404,187	33	1,617	2,045	1,237,560	300	192,000	98,077	2,550,020	22,419	1,843,649
1894.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

(*f*) From *Statistique de l'Industrie Minérale* and from *Annales du Commerce Exterieur.*
(*g*) Lead produced from native ore only; does not include the metal produced from foreign mineral imported into France to be desilverized.

The other production presents no special features of interest. The output of silver comes from the silver-lead mines of Pontgibaud and the Aveyron. The nickel reported is made in the works of the Société Nickel from ore brought from New Caledonia. A minor item which is perhaps worthy of note is the large comparative increase in the production of aluminum, which though still small in itself has increased fourfold in three years. This is made at Froges, the raw material coming from the bauxite deposits of the Isère.

For the following table of mineral and metallurgical imports for the 22 years from 1872 to 1893, inclusive, we are again indebted to the Ministry of Public Works. The table calls for little special remark. It may be noted that the coal imports have gradually increased, the consumption of mineral fuel having grown faster than the French production. The receipts of coal were mainly from the Belgian mines.

MINERAL AND METALLURGICAL IMPORTS OF FRANCE. (*h*) (IN METRIC TONS AND DOLLARS.)

Year	Bituminous Substances. (*i*)		Coal.		Copper.		Gold.	Silver.	Iron and Steel.		Castings.	
1872	151,532	$3,340,000	7,130,000	$29,680,000	11,489	$6,800,000	$28,400,000	$48,180,000	25,769	$260,000	57,997	$1,740,000
1873	130,505	4,520,000	7,461,000	48,500,000	18,570	8,820,000	35,520,000	77,820,000	24,791	2,480,000	48,844	1,360,000
1874	150,130	4,140,000	6,884,000	36,060,000	24,751	9,680,000	103,400,000	86,900,000	53,045	3,140,000	32,089	740,000
1875	116,327	3,780,000	7,656,000	36,640,000	17,058	6,820,000	121,600,000	53,360,000	44,364	2,800,000	63,337	1,340,000
1876	172,218	6,180,000	7,868,000	34,620,000	29,775	11,160,000	119,660,000	41,040,000	46,674	2,760,000	80,746	1,360,000
1877	206,484	6,720,000	7,512,000	31,900,000	20,149	8,080,000	106,920,000	29,620,000	63,459	2,640,000	101,401	1,380,000
1878	186,314	5,980,000	7,751,000	28,620,000	25,170	7,600,000	72,880,000	35,800,000	65,719	2,840,000	89,716	1,140,000
1879	194,766	5,000,000	8,423,000	29,100,000	24,290	7,060,000	38,800,000	27,560,000	59,482	2,840,000	79,368	960,000
1880	277,440	5,940,000	9,395,000	34,020,000	25,521	7,660,000	38,960,000	20,200,000	125,301	3,140,000	72,066	1,040,000
1881	286,812	6,880,000	9,267,000	34,140,000	29,244	8,840,000	46,700,000	26,020,000	209,154	4,980,000	191,091	2,680,000
1882	278,722	7,560,000	9,935,000	37,820,000	26,117	8,620,000	56,680,000	25,620,000	168,332	5,420,000	223,131	3,120,000
1883	299,190	7,720,000	10,556,000	33,480,000	31,425	9,840,000	12,920,000	16,280,000	129,195	3,880,000	238,150	3,200,000
1884	253,963	8,660,000	10,613,000	33,560,000	32,732	6,600,000	25,500,000	20,200,000	70,277	2,720,000	136,284	1,640,000
1885	368,669	9,220,000	9,943,000	29,200,000	24,131	6,020,000	48,720,000	47,130,000	53,349	2,160,000	91,010	1,000,000
1886	220,000	6,499,800	9,425,000	24,928,600	23,226	5,293,600	52,080,000	36,800,000	46,674	1,687,000	55,773	613,300
1887	200,500	5,829,600	9,540,000	25,231,200	28,706	6,697,200	18,640,000	35,600,000	31,642	1,631,600	25,068	275,800
1888	265,000	7,147,800	9,404,000	28,688,000	43,883	17,464,400	20,200,000	32,820,000	51,574	1,494,600	26,911	296,000
1889	266,000	8,678,400	8,961,000	42,438,800	12,946	4,056,400	67,520,000	22,120,000	47,518	1,219,000	13,025	151,000
1890	289,400	9,564,400	10,375,000	49,553,200	31,571	8,575,400	23,440,000	37,840,000	58,160	1,298,600	20,620	243,400
1891	273,000	8,743,600	10,542,000	37,954,200	30,074	8,694,000	72,500,000	35,280,000	45,856	1,228,600	56,756	681,000
1892	312,000	10,509,600	10,357,000	36,921,000	24,384	6,796,600	77,520,000	24,000,000	57,790	1,902,200	84,520	1,835,600
1893	360,000	11,689,600	11,401,000	36,464,800	29,880	7,276,200	61,094,356	31,743,279	82,529	2,000,600	93,616	2,262,800
1894	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Year.	Lead.		Nickel.		Nitrate of Soda.	Stone.	Sulphur.		Tin.		Zinc.	
1872....	38,613	$3,800,000	.....	.....	.....	.....	46,417	$1,320,000	3,563	$2,860,000	23,763	$2,780,000
1873....	33,511	3,760,000	25	.....	.....	.....	49,040	1,600,000	3,662	2,400,000	27,700	3,720,000
1874....	43,010	5,160,000	37	.....	.....	.....	48,386	1,580,000	3,952	2,020,000	23,889	2,860,000
1875....	40,283	4,360,000	5	.....	.....	.....	41,807	1,520,000	5,070	2,420,000	25,956	3,280,000
1876....	46,906	4,880,000	.....	.....	.....	.....	54,604	1,900,000	5,991	2,280,000	29,234	3,360,000
1877....	47,186	4,640,000	.....	.....	.....	.....	47,669	1,460,000	4,935	1,720,000	33,276	3,560,000
1878....	52,351	3,980,000	.....	.....	.....	.....	52,579	1,600,000	5,999	1,800,000	32,496	2,800,000
1879....	54,733	3,840,000	.....	.....	.....	.....	71,753	1,740,000	5,120	1,820,000	36,158	3,130,000
1880....	64,283	3,880,000	.....	.....	.....	.....	75,172	2,300,000	5,425	2,340,000	30,568	2,740,000
1881....	59,635	4,060,000	.....	.....	.....	.....	73,623	2,260,000	5,868	2,720,000	42,885	3,280,000
1882....	65,369	4,240,000	.....	.....	.....	.....	50,671	1,540,000	5,348	2,740,000	33,442	2,640,000
1883....	69,038	4,000,000	.....	.....	.....	.....	63,692	1,620,000	6,198	2,940,000	39,007	2,760,000
1884....	65,125	2,820,000	.....	$214,400	$3,800,000	$2,788,200	72,152	1,780,000	6,066	2,540,000	39,445	2,640,000
1885....	57,096	3,260,000	.....	420,600	3,579,600	2,807,400	66,071	1,520,000	5,038	2,320,000	32,737	2,580,000
1886....	61,682	3,889,800	.....	292,000	3,493,600	2,866,000	69,653	1,484,600	5,777	2,981,800	32,918	2,543,200
1887....	63,338	4,180,600	.....	380,400	4,328,600	2,883,400	75,522	1,451,600	6,090	3,384,000	35,036	2,841,000
1888....	52,709	3,708,800	.....	604,600	7,292,400	2,932,800	62,800	1,162,000	6,763	4,376,400	26,890	2,748,000
1889....	62,033	3,945,400	.....	681,600	8,170,800	2,832,800	74,047	1,350,000	5,650	2,650,400	27,009	2,756,400
1890....	69,881	4,480,200	601	750,800	8,219,600	3,036,800	84,394	1,744,000	6,063	2,863,000	28,304	3,202,200
1891....	74,502	4,506,600	801	1,031,400	7,519,400	3,972,800	88,678	2,416,000	6,204	2,847,000	30,449	3,447,000
1892....	72,721	5,166,200	2,703	1,456,400	9,013,600	4,456,000	98,721	2,329,200	7,085	3,382,600	29,884	3,305,400
1893....	77,679	5,262,800	1,866	1,046,200	60,234,400	4,925,800	98,750	2,329,200	7,890	3,683,000	35,200	3,781,200
1894....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

(*h*) From *Statistique de l'Industrie Minérale* and from *Annales du Commerce Exterieur.*
(*i*) Includes bitumen, bituminous schist and sand and asphaltic limestone.

The following table shows the imports of ores of different classes for the four years from 1890 to 1893, inclusive, and the imports of iron ore for 1894. With the exception of the decrease in 1891, the last named imports have shown a remarkable uniformity. They are furnished by Spain, Belgium and Algeria.

MINERAL IMPORTS OF FRANCE. (IN METRIC TONS.)

Year.	Lead Ore.	Copper Ore.	Antimony Ore.	Gold Ore, Kilos.	Iron Ore	Iron Pyrites Ore.	Manganese Ore.	Nickel Ore.	Silver Ore, Kilos	Tin Ore.	Zinc Ore.
1890..	2,126	5,080	196	.....	1,610,060	39,553	54,601	416	946,000	444	39,473
1891..	3,893	10,024	208	7,176	1,438,000	45,457	44,919	6,165	1,245,000	628	36,437
1892..	7,281	16,850	123	13,277	1,684,000	47,502	43,888	11,927	3,539	523	41,931
1893..	5,261	20,527	175	2,606	1,630,000	56,505	35,531	18,236	4,092,000	78	34,221
1894..	.....	.....	.....	.....	1,638,000	.....	.....	.....	.....	.....	.....

The exports for five years past are shown in the following tables; the particulars for the years prior to 1890 will be found in THE MINERAL INDUSTRY, Vols. I. and II. The statements for recent years present few features of especial interest. The exports of iron ore, it will be noted, have shown very slight changes for three years past; in 1894 they were less than for several years previously.

MINERAL AND METALLURGICAL EXPORTS OF FRANCE. (*f*) (IN METRIC TONS.)

Year.	Aluminum Metal.	Antimony.		Copper.		Gold.		Iron.					Lead.	
		Ore.	Metal	Ore.	Metal	Ore.	Metal	Ore.	Pyrites.	Pig.	Casting	Steel.	Ore.	Metal.
1890....	.....	1,666	140	12,083	5,060	.....	5,953	285,000	15,908	219,122	233,980	69,344	12,879	9,895
1891....	.....	1,153	78	11,802	6,528	.....	6,045	299,000	12,120	196,271	145,412	54,019	13,280	10,657
1892....	42	1,333	90	12,387	8,526	.....	4,222	305,000	22,455	161,173	159,453	30,323	10,823	10,057
1893....	43	492	165	10,198	7,601	5,211	4,222	302,000	38,060	130,028	143,652	28,426	14,032	9,243
1894....	.....	.....	.....	.....	.....	.....	.....	247,627	.....	.....	.....	.....	.....	.....

Year.	Manganese Ore.	Mercury, Metallic.	Nickel.		Silver, Kilos.		Tin.		Zinc.	
			Ore.	Metal.	Ore.	Metal.	Ore.	Metal.	Ore.	Metal.
1890.....	595	10	48	90	7,908	24,085	61	921	24,050	5,156
1891.....	1,494	6	26	210	103,222	17,800	88	1,014	31,662	5,177
1892.....	8,541	5	455	319	195	18,950	222	918	32,023	7,034
1893.....	12,133	5	701	191	61,219	21,642	.....	973	47,426	8,819
1894.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

(*f*) From *Statistique de l'Industrie Minérale.*

Algeria.—In the following tables are given the production and the imports for three years of the French colony of Algeria, which has a somewhat varied mineral industry, not yet developed to a great extent. Zinc ore, copper and iron ore are the leading items of this production. The two former are increasing steadily. The iron ore production has fallen off, owing largely to the withdrawal of the demand from England which is now more readily supplied from Spain and from Scandinavia. At one time a considerable amount of iron ore was exported from Algeria to the United States, but the Cuban ores have taken their place and the Algerian mines no longer ship to America.

MINERAL EXPORTS OF ALGERIA. (IN METRIC TONS.)

Year.	Lead and Copper Ore.	Zinc Ore.
1891	13,928	9,748
1892	12,959	21,496
1893	6,762	27,844
1894	.....	.....

MINERAL PRODUCTION OF ALGERIA. (*k*) (IN METRIC TONS; 5f.=$1.)

Year.	Antimony Ore.		Copper Ore.		Iron Ore.		Iron, Cast.		Lead-Silver Ore.		Quicksilver Ore.		Zinc Ore.		Copper Matte.		Salt, Sea.	
1892	48	$2,470	21,907	$281,022	452,603	$807,140	445	.....	349	$7,463	178	$1,323	21,907	$281,022	448	.....	24,784	$10,408
1893	79	4,740	24,390	197,866	393,921	702,388	...	.....	212	4,181	757	9,806	24,390	197,866	....	.....	19,008	93,420
1894	..	.....	.....	.....	.....	.....	...	.....	...	.....	....	.....	.....	.....	....	.....	.....	.....

(*k*) From *Statistiques des Richesses Minérales*, 1894, and *Statistiques de l'Industrie Minérale*, 1893.

Tunis, which is now a French protectorate, and is practically a French colony, is beginning to make returns of its production. The mineral resources of the regency are considerable, and a rapid development may be expected, especially in the production of mineral phosphates. To the latter reference is made in another part of this volume at considerable length.

VALUE OF IMPORTS AND EXPORTS OF TUNIS. (*l*) (£1=$5.)

	IMPORTS.						EXPORTS.
Year.	Building Materials.	Coal.	Iron, Steel, Including Rails.	Marble.	Machinery.	Metal Goods.	Mineral Oils.	Zinc.
1891	$65,380	$121,550	.....	.....	$109,660	.....	$43,110	$935
1892	159,850	121,180	$88,075	$23,385	88,675	$704,500	67,755	49,030
1893	.....	.....	.....	.....	.....	.....	.....	.....

(*l*) From British Diplomatic and Consular Reports, Annual Series, No. 1293, August, 1893.

A company has lately been organized which has obtained a concession to work the phosphate deposits of Gafsa and to build a railroad from Sfax to Gafsa. This line will be of great service in developing the mineral resources of the regency.

The total shipments of phosphates from the port of Bona in Algeria for the year 1894 were 49,593 (metric) tons. Of this 25,915 tons went to England; 8480 tons to Italy; 5325 tons to Austria; 3145 tons to France, and 6728 tons to other countries.

GERMANY.

THE mineral-production of Germany has been for a number of years free from violent fluctuations and has shown a steady and healthy growth. During 1893 and 1894 it suffered comparatively little from the universal trade depression which dated in Europe from the close of 1891 and reached our own country over a year later. Perhaps the most marked features of the German returns in recent years have been the growth in importance of the iron industry and the leading position held in the chemical industry. The German output of iron and steel is now exceeded by those of Great Britain and the United States, and the growth has been a continuous one. Almost the same thing can be said of the coal production, which in 30 years has grown from 22,000,000 tons to 76,000,000 tons annually. A large part of this increase has been absorbed by the iron and other metallurgical industries and by the growth of manufactures.

It is a characteristic of the German thoroughness that greater advance has been made there than in any other country in utilizing the by-products and waste from industrial operations, such, for instance, as the waste gases from coke ovens, which are almost universally saved and treated for tar, sulphate of ammonia and other products. Undoubtedly this careful treatment and economy in operation has contributed much to the growth of the German industry and has enabled the German manufacturers to increase their export trade and the sale of their products abroad to the extent which has been apparent in recent years.

The following tables show the mineral production of Germany for the five years from 1890 to 1894 inclusive; the statistics for the years previous to 1890 will be found in THE MINERAL INDUSTRY, Vols. I. and II.

MINERAL PRODUCTION OF GERMANY AND LUXEMBURG. (*a*) (IN METRIC TONS; 4 marks=$1.)

Year	Antimony Ore.		Arsenic Ore.		Asphaltum.		Boracite.		Coal.		Cobalt, Nickel & Bismuth Ore.		Copper Ore.	
1890	1	$75	2,655	$32,058	51,144	$94,497	182	$13,710	70,237,808	$134,511,033	976	$159,338	596,100	$5,041,683
1891	1	41	3,124	32,563	49,150	93,928	177	12,660	73,715,653	147,379,551	1,074	159,328	587,626	5,216,192
1892	...	.....	2,146	19,491	53,279	104,713	179	13,614	71,372,193	131,744,794	3,185	198,208	567,738	5,128,386
1893	16	100	2,756	25,363	47,238	89,245	162	11,662	73,908,990	124,616,605	4,490	189,410	584,875	4,530,683
1894	...	.....	2,906	30,006	55,981	112,762	222	11,589	76,772,659	127,294,092	4,525	194,588	588,195	4,060,039

Year.	Epsomite.		Graphite.		Iron Ore.		Iron Pyrites.		Other Vitriol & Alum Ores.		Kainit.	
1890.....	8,030	$17,449	4,355	$73,921	11,406,132	$11,957,255	122,372	$251,939	1,379	$1,921	361,827	$1,299,939
1891.....	7,454	16,314	3,824	73,540	10,657,521	9,852,076	128,288	239,468	2,406	1,517	472,256	1,701,640
1892.....	10,207	22,331	4,036	63,240	11,539,033	10,319,938	115,243	215,887	2,973	2,016	549,445	1,955,717
1893.....	8,818	17,057	3,140	52,010	11,457,491	9,950,140	121,334	219,427	791	1,199	664,986	2,397,774
1894.....	8,252	17,999	3,133	45,757	12,392,065	10,544,385	134,787	244,865	464	920	727,234	2,574,805

Year.	Other Potash Salts.		Lead Ore.		Lignite.		Manganese Ore.		Petroleum.	
1890.....	913,030	$2,826,199	168,234	$4,524,580	19,055,026	$12,442,209	41,841	$196,379	15,226	$310,508
1891.....	898,993	2,771,494	159,215	4,163,988	20,536,625	13,541,457	40,335	202,445	15,315	298,659
1892.....	802,630	2,532,169	163,372	3,671,881	21,171,857	14,626,475	32,861	126,924	14,527	219,941
1893.....	861,162	2,762,060	168,414	3,536,042	21,567,218	13,750,754	40,788	122,987	13,974	195,736
1894.....	916,339	2,988,403	162,675	3,025,884	22,103,446	13,287,699	43,702	116,412	17,232	243,112

Year.	Rock Salt.		Silver and Gold Ore.		Tin Ore.		Uranium and Wolfram Ore.		Zinc Ore.	
1890.....	557,060	$618,301	21,360	$1,146,000	102	$29,267	42	$9,274	759,437	$5,853,998
1891.....	666,793	744,754	22,569	1,151,723	75	22,839	47	10,564	793,544	6,238,384
1892.....	662,577	708,046	17,536	910,501	63	23,001	48	11,707	800,237	5,305,324
1893.....	669,042	736,029	18,778	773,931	69	18,888	44	10,778	788,394	3,574,162
1894.....	735,490	789,267	19,080	629,672	21	375	40	6,194	728,616	2,569,514

METALLURGICAL PRODUCTION OF GERMANY.

Year.	Antimony and Alloys.		Arsenical Products.		Cadmium, Kilos.		Copper, Matte and Black.		Copper, Pig.		Gold, Kilos.	
1890.....	*b*139	$31,732	2,167	$147,241	4,157	$3,788	793	$66,026	24,437	$7,220,606	1,855	$1,290,417
1891.....	*b*198	43,175	1,988	138,626	2,797	2,468	596	46,139	24,092	6,952,884	3,077	2,141,998
1892.....	*b*249	44,931	1,667	109,127	3,200	2,850	625	24,630	24,781	6,189,532	3,859	5,683,944
1893.....	407	64,485	1,794	119,588	5,000	5,461	842	63,735	2,400	5,858,500	3,079	2,138,250

Year.	Iron.		Lead, Pig.		Litharge.		Mineral Paints.		Nickel Products. (*c*)		Silver, Kilos.		Sulphur.	
1890	4,658,451	$66,894,961	101,781	$6,407,359	3,972	$264,071	2,112	$56,653	934	$1,372,069	402,945	$14,037,716	1,915	$44,810
1891	4,631,218	58,107,003	95,615	5,816,587	3,124	197,317	2,332	61,820	1,062	1,606,200	444,852	14,749,420	2,020	51,050
1892	4,937,461	57,324,072	97,742	5,136,861	3,468	201,765	2,629	68,313	1,238	1,713,556	489,350	14,307,172	5,155	54,460
1893	4,986,030	54,986,500	74,659	4,519,250	3,551	183,181	2,993	84,008	1,402	1,703,286	449,383	11,766,155	2,151	51,308

Year.	Sulphuric Acid.		Sulphate.						Tin.		Zinc.	
			Copper.		Iron.		Zinc & Nickel.		Mixed.					
1890.....	464,044	$3,820,918	5,854	$624,757	8,351	$57,401	3,769	$60,683	344	$11,023	64	30,887	139,266	$15,598,177
1891.....	467,633	4,018,746	3,502	288,938	.....	.....	4,117	103,453	298	10,038	287	131,131	139,353	15,639,337
1892	488,047	3,716,014	4,024	281,234	9,393	53,854	4,479	92,372	217	7,684	684	309,973	139,938	13,765,510
1893.....	517,790	3,887,500	4,773	353,351	8,457	41,763	4,648	84,305	233	8,535	951	348,135	142,956	11,821,500

FINISHED PRODUCTS OF GERMAN SALT WORKS.

Year.	Alum.		Alumin. Sulphate.		Common Salt.		Glauber Salt.		Magnesium Chlor.	
1890.....	4,460	$136,611	31,010	$554,160	492,584	$3,321,576	68,716	$434,831	14,958	$37,453
1891.....	5,619	137,590	28,710	541,805	503,386	3,355,586	.....	.....	15,619	39,528
1892.....	4,270	117,465	29,588	570,735	504,687	3,460,869	73,988	502,750	14,386	50,828
1893.....	4,102	115,075	27,012	505,165	545,973	3,404,250	75,965	486,250	12,764	44,493
1894.....	3,914	107,092	26,804	480,176	517,536	3,544,440	66,309	392,640	17,422	50,913

Year.	Magnesium Sulphate.		Potassium Chloride.		Potassium Sulphate.		Double Sulph. of Potas. Magnes.	
1890.....	26,376	$79,778	137,005	$4,433,685	31,126	$1,233,036	11,094	$214,629
1891.....	23,126	71,126	129,512	4,282,290	.....	.....	10,508	199,155
1892.....	23,879	84,008	123,962	4,106,579	22,968	931,750	11,593	228,172
1893.....	27,548	79,250	137,216	4,326,250	22,555	956,500	14,129	288,750
1894.....	28,628	88,814	149,775	4,722,049	23,281	958,736	14,156	274,694

(*a*) From *Vierteljahrs und Monatshefte zur Statistik des Deutschen Reichs;* 1894 are taken from *Deutsche Kohlen-Zeitung*, March 28, 1895.

(*b*) Includes manganese.

(*c*) The nickel products include bismuth, cobalt and uranium salt.

The additional tables below give in detail the mineral production of Prussia, the totals of which are included in the tables above. In the same way we have added the returns furnished us of the mineral productions of Saxony, of Bavaria, and of Baden. In the statement of Saxony the report of the production of the ores treated at the furnaces at Freiberg will be found of special interest.

MINERAL PRODUCTION OF PRUSSIA.(*a*) (IN METRIC TONS; 4 marks=$1.)

Year.	Alum Shale.		Antimony Ore.		Arsenic Ore		Asphalt.		Boracite.		Coal.		Lignite. (*b*)	
1890	911	$648	....	.....	2,183	$27,728	14,533	$50,079	176	$13,260	64,373,816	$119,880,961	15,468,434	$9,967,812
1891	2,163	963	....	.....	2,169	25,864	11,217	36,021	150	11,073	67,528,015	131,806,263	16,739,984	10,892,089
1892	2,460	1,087	....	.....	1,202	12,229	12,665	35,956	168	12,953	65,442,558	117,677,458	17,219,033	11,913,033
1893	302	418	15	75	1,634	16,384	11,290	34,730	139	13,037	67,657,844	110,084,144	17,566,137	11,184,614

Year.	Cobalt Ore.		Copper Ore.		Epsom Salt.		Graphite.		Iron Ore.		Iron Pyrites.		Kainit.	
1890	651	$10,739	587,722	$4,978,543	6,688	$14,311	....	.....	4,243,399	$7,899,970	111,291	$216,961	308.660	$1,095,891
1891	576	9,209	578,256	5,149,521	6,421	13,896	....	.....	2,903,811	6,207,238	119,100	213,457	399,007	1,421,727
1892	534	14,550	557,172	5,073,704	8,518	18,423	....	.....	4,081,306	6,388,537	104,346	184,851	448,095	1,562,839
1893	203	8,491	573,721	4,471,014	7,721	14,656	....	.....	4,007,898	6,036,567	110,072	192,937	531,560	1,904,822

Year.	Other Potash Salts.		Lead Ore.		Manganese Ore.		Nickel Ore.		Petroleum.		Quicksilver Ore.		Rock Salt.	
1890...	708,467	$1,937,579	148,615	$4,349,864	40,131	$181,696	33	$409	2,249	$84.545	....	.....	250,351	$303,086
1891...	617,638	1,712,988	140,123	4,000,998	36,860	181,899	185	1,452	2,498	76,050	....	.....	283,924	321,893
1892...	501,748	1,439,801	141,660	3,462,955	31,388	106,087	529	4,500	1,585	41,925	....	.....	245,550	253,628
1893...	596,062	1,769,353	148,441	3,364,366	39,132	97,830	652	8,090	1,365	36,592	1.2	$25	260,727	280,259

Year.	Silver and Gold Ore.		Zinc Ore.		Antimony and Alloys.		Arsenic Products.		Bismuth.		Cadmium, Kilcs.		Cobalt Prod.	
1890.....	152	$13,594	757,862	$5,843,854	115	$16,899	817	$41,108	.....	.....	4.187	$3,789	40	$197,440
1891.....	131	20,610	792,351	6,230,590	165	23,750	812	41,379	.....	.....	2,797	2,468	44	198,740
1892.....	4	11,498	797,698	5,294,549	210	23,106	592	22,739	.....	.....	3,200	2,850	54	239.909
1893.....	12	18,665	787,048	3,507,104	362	39,898	709	31,939	0.648	$174	5,284	5,461	44	190,315

Year.	Copper.		Copper, Pig.		Gold, Kilos.		Iron, Pig.		Lead, Pig.		Litharge.	
1890.....	793	$66,026	21.779	$6,430,001	127.67	$89.795	3,288,369	$49,127,521	91,133	$5,712,706	2.907	$190,453
1891.....	547	43,150	21,236	6,102,910	100.31	69,790	3,288,441	43,832,358	87,372	5.286,817	2,246	142,510
1892.....	625	24,630	21,559	5,383,722	115.82	81,067	3,439,081	42,515,551	87,983	4,607,369	2,634	153,143
1893.....	831	65,666	20,707	5,045,292	738.75	513,707	3,539,701	41,118,869	85,866	4,166,992	2,548	139,304

Year.	Manganese and Alloys.		Nickel and Alloys.		Paint, Mineral.		Salt, Common.		Silver, Kilos.		Sulphhr.		Sulphuric Acid.	
1890	24	$14,833	434	$466,783	1,659	$33.885	271,615	$1,721,098	260,824	$9,046,996	1,603	$40,098	340,512	$2,746,565
1891	33	19,425	594	689,405	1,813	35,863	265,549	1,675,428	277,546	9,254,830	1,721	46,528	343,826	2,938,186
1892	39	21.825	747	747,312	2,082	40,320	264,896	1,695,904	301,374	8,786,415	1,850	49,828	360,156	2,722,789
1893	44	24,590	896	900,339	2,415	55,171	266,478	1,707,265	276,645	7,276,755	1,871	77,659	387,306	2,977,760

Year.	Sulphates.										Tin.		Zinc.	
	Copper.		Iron.		Nickel.		Zinc.		Mixed.					
1890	2.182	$217.051	6,384	$39,905	26	$8,250	1,944	$28,458	281	$8,302	.....	.....	139,056	$15,574,109
1891	1,285	109,032	7,682	51,344	45	14.000	2,405	36.723	223	6,723	238	$107.778	139,147	15,616.909
1892	1,338	95,056	7.778	41,692	44	14,000	2,748	40,886	167	5,506	644	290,720	139.725	13,743,287
1893	1,872	135,231	7,134	30,765	44	11,237	2,704	37,111	187	6,298	909	329,790	142,773	11,806,066

(*a*) From *Zeitschrift für das Berg- Hütten-und Salinenwesen.*

MINERAL PRODUCTION OF SAXONY. (*b*) (IN METRIC TONS; 4 marks=$1.)

Year.	Arseno-pyrites.		Bismuth, Cobalt, and Nickel Ores.		Coal.		Lignite.		Iron Ore.		Manganese Ore.		Pitch-Blende.		Tin Ore.	
1890	1	$27	187	$153.403	4,150,842	$10,289,151	848,053	$634,739	10,808	$28,079	792	$3,008	5	$3,552	60	$29,267
1891	...	.....	291	148,379	4,366,819	10,957,819	864,376	657,733	14,159	36,912	2,046	4,717	....	.....	50	22,758
1892	...	.....	2,113	183,261	4,212,875	9,939,670	927,860	674,682	12,895	23,945	1,638	3,699	....	.....	49	18,945
1893	...	.....	3,634	174,917	4,274,064	10,128,936	940.988	663,831	1,650	2,972	.....	.....	....	.....	49	18,908

MINERAL PRODUCTION OF SAXONY—*Con.*

Year.	Wolfram Ore.		Mixed Ores. (*c*)		Other Minerals. (*d*)		Total.
1890	37	$5,722	31,498	$1,163,737	2,250	$18,249	$12,329,147
1891	42	8,212	31,909	1,164,205	3.136	16,891	1 ,017,626
1892	37	8,108	30,231	1,025,078	3,212	15,256	11,892,644
1893	42	7,866	31,565	1,000,077	2,425	4,547	12,002,554

METAL CONTENTS OF THE MIXED ORES TREATED AT THE ROYAL SMELTING WORKS AT FREIBERG. (*b*) (IN METRIC TONS.)

Total of Mixed Ores.		Arsenic.	Copper.	Gold, Kilos.	Lead	Nk'l and Cobalt.	Silver, Kilos.	Sulphur	Zinc.
31,498	$1,163,737	528	16	0.184	3,583	2.97	34,151	4,935	151
31,528	1,159,029	462	18	0.286	4,253	0.97	34,499	4,619	318
30.015	1,023,215	415	13	0.0496	4,163	0.55	34,908	4,208	338
31,335	869,041	406	20	.....	4,361	0.65	33,253	4,841	188

PRODUCTS SOLD BY THE ROYAL SMELTING WORKS AT FREIBERG AND THE BLUE-COLOR WORKS AT SCHNEEBERG. (*b*) (IN METRIC TONS.)

Year.	Arsenic Products. (*e*)	Bismuth.	Cobalt (*f*) Products.	Copper Sulph	Gold, Kilos.	Lead Prod. (*g*)	Lead, Sheet	Lead, Shot.	Lead, other Mf'es of. (*h*)	Nickel Speiss.	Silver. Kilos.	Sulphuric Acid (*i*)	Other Chemicals.	Zinc and Zinc Gray.
1890.....	1,342	1.9	453	2,404	778.155	4,393	1,330	248	612	35	84,201	16,653	1,082	210
1891.....	1,170	2.5	416	1,750	949.657	4,159	1,200	193	179	56	83,513	13,832	726	207
1892.....	1,075	2.0	407	1,975	778.406	6.054	565	187	356	49	94,830	10,860	932	212
1893.....	1,084	2.1	445	2,024	953.650	5,456	642	194	454	54	95,102	14,409	690	182

(*b*) From *Jahrbücher für das Berg- und Hüttenwesen im Königreiche Sachsen.* (*c*) See the appended table of Metal Contents of Mixed Ores Treated at the Royal Smelting Works at Freiberg. (*d*) Fluorspar, barytes, mineral paint, etc. (*e*) Including arsenious acid, red, yellow, and white glass, and metallic arsenic. (*f*) Product of the blue-color works at Schneeberg. (*g*) Including soft lead, antimonial lead, litharge, etc. (*h*) Lead pipe, etc. (*i*) Including sulphuric acid of various sorts.

MINERAL PRODUCTION OF BADEN. (*a*) (IN METRIC TONS; 4 marks=$1.)

Year	Coal.		Clay, Fire.		Gypsum.		Iron, Cast, 2d Fusion.		Iron Ing's (Steel.)		Iron, Wrought.		Lead Ore.		Limestone, etc.	
1890	5,167	$17,693	2,491	$3,155	24,835	$19,093	24,965	$1,174,722	53	$4,100	3,117	$168,974	1	$105	5,480	$1,470
1891	5,616	16,744	2,485	3,140	22,086	15,326	25,215	1,160,640	58	4,063	2,833	126,093	13	1,507	5,700	1,290
1892	4,500	13,000	8,139	7,760	22,129	14,729	24,910	1,138,148	80	1,062	2,733	123,202	6	454	4,441	1,181
1893	3,200	9,200	8,475	6,647	28,904	16,217	24,940	1,167,990	188	23,562	644	38,351	5	415	4,170	1,122

Year.	Manganese Ore.		Quartz-sand.		Salt.		Sandstone.		Sulphate of Alumina.		Sulph. Acid.		Tripoli.		Zinc Ore.		Total.
1890	..	.....	2,036	$1,647	27,819	$202,454	10	$45	2,000	$33,750	9,872	$86,380	12	$1,447	1,282	$7,692	$1,723,627
1891	30	$232	1,714	1,612	29,493	196,663	87	415	1,768	39,776	10,633	106,327	12	1,447	97	728	1,676,003
1892	6	15	3,027	1,609	29,463	208,984	5	125	3,476	82,564	12,331	123,315	10	1,005	1,530	6,120	1,723,237
1893	5	12	1,924	1,048	28,472	211,486	8	200	1,498	33,705	12,572	94,296	8	763	484	1,451	1,606,465

MINERAL PRODUCTION OF BAVARIA. (*b*) (IN METRIC TONS; 4 marks=$1.)

Year.	Antimony Ore.		Barytes.		Building Stones.		Cement.		Coal.		Lignite.	
1890.....	1.00	$75	5,114	$13,023	575,016	$891,265	76,135	$73,839	740,753	$1,992,507	8,117	$10,187
1891.....	0.59	40	5,124	9,962	612.657	998,182	71.648	68,104	756,148	2,012,768	10.044	11,762
1892.....	.....	.....	4,765	9,543	582,784	883,062	87,571	78,798	713,052	1,815,415	13,367	15,662
1893.....	.....	.....	.....	.....	568,410	836,689	79,779	80,386	802,537	2,000,357	17,167	14,518

Year.	Copper Ore.		Emery.		Feldspar.		Fire Clay.		Flagstones.		Fluorspar.		Graphite.	
1890	50	$125	275	$2,484	999	$3,596	91,009	$182,452	19,597	$49,392	4,223	$4,076	4,355	$73,921
1891	.....	.....	184	1,511	1,445	2,890	103,287	206,674	20,772	69,005	7,847	8,420	3,824	73,540
1892	1,831	7,706	170	1,710	1,200	2,400	108,312	237,056	19,538	79,930	4,594	5,907	4,036	63,240
1893	650	2,762	172	1,498	1,200	2,400	110,970	217,859	26,873	110,493	3,988	4,473	3,140	52,010

Year.	Gypsum.		Iron Ore.		Iron Pyrites.		Kaolin.		Limestone.		Lithographic Stone.		Manganese Ore.	
1890	32,631	$9,562	153,768	$155,867	1,741	$4,138	18,635	$22,773	182,616	$50,393	11,485	$401,975	187	$562
1891	30,197	10,407	149,653	150,720	1,933	4,833	18,320	19,284	224,185	61,431	8,775	219,375	260	650
1892	24,517	12,764	146,392	149,004	1,945	4,862	18,085	17,232	233,417	64,716	8,650	216,262	137	275
1893	25,540	14,275	149,270	139,610	2,107	5,269	17,835	22,117	283,488	76,376	8,885	23,464	180	445

Year.	Ocher and Mineral Paints		Quartzsand.		Salt, Rock.		Sandstone.		Slate.		Soapstone.		Whetstone	
1890	6,855	$27,116	27,936	$7,735	665	$4,236	237,030	$312,679	1,127	$9,742	1,351	$26,075	88	$2,188
1891	5,710	14,750	32,974	11,271	1,042	6,638	221,575	307,117	1,433	12,127	1,145	22,930	109	2,075
1892	8,877	20,773	32,381	10,963	955	6,115	246,193	319,562	1,463	13,005	1,271	20,343	147	2,802
1893	10,317	31,168	15,325	5,531	1,214	7,654	238,405	314,290	1,485	12,886	1,911	29,320	57	1,300

Year.	Zinc and Lead Ore.		Iron, Pig.		Iron, Cast, 1st Fusion.		Iron, Cast, 2d Fusion.		Iron, Bar.		Iron, Sheet.		Iron, Wire.	
1890	1,127	$22,548	66,517	$863,565	187	$7,459	53,567	$2,671,410	68,684	$2,567,147	3,511	$161,161	4,983	$165,573
1891	.....	.....	76,552	883,823	213	7,999	52,257	2,523,427	64,742	2,187,057	282	12,519	1,644	46,080
1892	.....	.....	77,598	898,302	334	12,521	48,212	2,249,683	64,646	2,020,865	592	22,349	1,008	28,035
1893	.....	.....	75,209	856,182	206	6,959	49,614	2,307,051	49,908	1,483,411	1,482	57,766	307	8,211

Year.	Steel.		Lead.		Salt.		Sulphate of Soda.		Other Sulphates and Alum.		Sulphuric Acid.	
1890	47,917	$1,438,886	1,989	$125,533	40,718	$444,977	404	$3,521	833	$43,044	7,914	$79,226
1891	67,088	1,834,077	.....	.....	40,629	439,614	466	3,800	662	29,198	7,520	70,500
1892	70,790	1,887,673	.....	.....	41,352	444,192	516	4,617	612	29,597	6,566	62,192
1893	60,824	1,645,074	.....	.....	42,153	459,596	1,229	3,750	628	27,873	7,355	15,942

(*a*) Statistics for Baden, 1890 to 1893, were compiled for THE MINERAL INDUSTRY by the *Domanendirection*, Carlsruhe. The production of iron ore in 1892 was 10.5 tons, valued at $116

(*b*) From the *Uebersicht der Production des Bergwerks-Huetten und Salinen Betriebes in dem Bayerischen Staate.* In 1890 there was also produced 260.4 kilos silver, valued at $8450.

The depression in business has affected the German industries to a greater extent through the reduction in prices than through any diminution in demand. The lower prices were felt with special force in the iron and steel industries, and in Germany, as in all the markets of the world, sales were made at the lowest rates ever recorded. An attempt made by the Westphalian, the Silesian and other local unions of iron-makers to maintain prices did not produce the desired results and the competition continued to a great extent unchecked among the different districts. Some benefit was derived from the operation of the new commercial treaty which ended the tariff war between Germany and Russia and once more opened to the German works a market from which they had been practically shut out for several years. The new business from this source, however, was not as great in amount as had been expected in 1894; although the indications are that during the current year there will be a considerable increase. The Russian works have not been able to supply the unusual demand for rails and other railroad material resulting from the building of several important new lines, and a considerable portion of the deficit will be supplied from Germany. Upon the whole, however, the year can hardly be said to have been a prosperous

one in the iron business, and many complaints were made that the margin of profit was extremely narrow, and that in some cases there was no margin at all. The cost of production had been brought down in previous years to a very low point, leaving, it is claimed, but little opportunity for further reductions. The German works, however, were generally free throughout the year from labor troubles and were able to continue work without interruption.

The Silesian zinc mines and works continued to produce upon a large scale although they also suffered from the low price of the metal. The attempt to renew the old convention among the European zinc producers did not succeed, owing to the reluctance of the different producing districts to give way and bring down their output below the figures attained in 1893. Towards the close of 1894 a new effort was made to negotiate an agreement, but it met with the same lack of success as the previous attempt.

No special progress in methods of mining or of metallurgy is to be recorded in Germany during the year. The principal attention in the way of improvement has been devoted to economy in fuel in the iron industries and to improvement in the making of coke, which had already been carried to a greater degree of perfection probably in Germany than in any other country, at least as far as economy and the utilization of by-products is concerned.

Reference has already been made to the chemical industry, and while no notable changes are to be recorded those industries are steadily gaining ground, and Germany seems determined to maintain a leadership in that production, not only in the extent of its production but in the perfection of its processes. The exports of chemical products are steadily increasing.

IMPORTS AND EXPORTS.

The tables below show the mineral imports of Germany for the five years now under review. The coal and coke imports are chiefly from Belgium and a large part of the quantity reported is used in the Luxemburg furnaces. Most of the pig iron reported is also from Belgium. The lignite comes chiefly from Austria and is used in the provinces adjoining the Austrian frontier. Iron ore comes from Sweden, Spain and Belgium; the Swedish imports have in recent years attained considerable importance in quantity.

MINERAL IMPORTS OF GERMANY. (*a*) (IN METRIC TONS.) (Unit of value, $1000.)

Year.	Alabaster and Marble.		Alum.		Ammonia, Sulph. of.		Brass, Copper, Aluminum, and Nickel Ware.		Coal.		Coke.		Lignite.		Cobalt and Nickel Metal, Crude.	
1890	20,213	$1,011	272	$9	33,873	$2,033	3,273	$2,150	4,164,538	$15,883	351,258	$1,967	6,506,404	$6,507	646	$888
1891	19,003	950	157	5	31,110	1,867	2,126	1,498	5,032,826	19,219	318,798	1,731	6,805,586	6,806	784	1,078
1892	21,298	959	....	...	34,207	1,881	*b*1,474	*b*1,125	4,436,983	14,870	465,726	2,147	6,701,309	6,366	1,356	1,611
1893	21,520	650	....	...	42,596	2,550	*b*1,467	*b*1,050	4,664,048	14,925	439,182	1,725	6,705,672	6,375	1,006	950
1894	.....	.....	....	...	36,634	.....	.....	.....	4,805,971	.....	404,178	.....	6,668,161	.....	1,236	

Year.	Copper Bars, Sheets, and Wire.		Copper, Pig.		Gold and Silver, Articles of.		Gold, Coined.		Gold, Crude and Bars.		Gold and Silver, Platinum Ores.		Iodine.		Iron Ore.	
1890	906	$339	31,432	$9,272	27	$1,330	33	$20,369	7	$5,093	13,756	$3,783	138	$916	1,522,501	$5,297
1891	1,104	369	34,182	9,400	28	2,378	58	36,350	27	18,893	18,962	5,215	156	1,035	1,408,025	4,862
1892	912	300	32,498	7,962	30	1,242	45	28,045	24	16,572	19,308	5,551	169	1,119	1,655,843	5,589
1893	599	175	38,455	8,850	32	1,300	26	16,050	27	18,975	20,516	5,125	324	2,150	1,573,202	5,250
1894	495	.....	37,031	.....	....	.....	...	.....	....	.....	13,935	.....	242	.....	2,093,070	.....

Year.	Iron, Pig.		Iron Wire.		Iron, Wrought.		Iron, Various Manufactures of.		Kaolin, Feldspar, Fire Clay.		Lead, Pig.		Lead and Copper Ores.		Lead, Tin and Zinc—Fine Manufac's of.	
1890	385,328	$5,591	5,732	$526	28,942	$1,339	40,674	$9,224	157,311	$1,573	12,766	$862	54,572	$7,504	223	$183
1891	244,852	3,264	5,692	478	22,364	929	44,346	5,794	153,750	1,538	17,625	1,091	49,040	6,130	189	144
1892	209,306	2,519	4,675	375	21,085	831	31,885	3,225	151,398	1,514	17,501	941	43,893	3,292	.....	.....
1893	218,998	2,475	4,946	400	17,054	625	32,494	3,000	141,096	1,325	23,857	1,200	43,490	2,925	.....	.....
1894	203.974	.....	.....	.....	19,966	.....	.....	.....	.....	.....	24,208	.....	51,304	.....	.....	.....

Year.	Lime, Chloride of.		Limestone and Mortar.		Lubricating Oil, Mineral.		Machinery.		Petroleum.		Phosphate of Lime.		Superphosphate.	
1889	4,716	$189	190,204	$1,094	44,565	$1,894	45,799	$8,013	625,668	$20,334	86,268	$1,618	124,962	$3,062
1890	6,647	216	173,612	998	52,311	2,289	56,942	10,485	646,804	18,272	115,524	2,166	148,440	4,056
1891	3,431	120	164,029	820	60,666	2,578	42,713	7,776	675,528	16,348	92,411	1,733	114,011	3,135
1892	.....	.....	174,483	873	63,150	2,684	.....	.....	743,433	15,185	169,798	2,972	86,851	1,954
1893	.....	.....	200,165	1,000	70,576	4,400	.....	.....	765,100	9,575	226,923	2,825	110,876	1,800
1894	.....	.....	.....	.....	.....	.....	.....	.....	785,100	.....	.....	.....	124,373	.....

Year.	Precious Stones.		Pyrites.		Salt.		Silver.				Silver and Gold, Refuse.		Slags.		Slate.		Soda, Crude and Crystals.	
							Coined.		Crude and Bars.									
1890	136	$2,797	210,725	$1,054	20,961	$105	23	$741	43	$1,494	28	$3,405	423,532	$1,112	68,695	$1,183	82	$1
1891	139	2,730	238,644	1,193	20,751	311	28	845	69	2,297	34	4,162	361,457	949	66,587	1,147	90	1
1892	95	1,762	218,272	982	24,533	218	30	783	64	1,871	35	4,230	410,631	1,283	62,566	1,095	293	5
1893	73	500	274,766	1,305	23,645	93	24	475	78	2,025	41	4,905	477,182	1,670	61,543	1,075	242	4
1894	...	.....	.....	.....	19,631	....	....	....	....	.....	...	.....	.....	.....	.....	.....	328	.....

Year.	Soda and Bicarbonate of Soda. Calcined.		Soda, Caustic.		Soda, Nitrate of.		Stone, Rough or Hewn.		Tin.				Zinc.			
									Pig.		Plate.		Ore.		Pig.	
1890	847	$24	710	$39	344,209	$13,768	696,638	$6,252	9,013	$4,281	4,296	$376	38,099	$953	8,625	$895
1891	569	17	350	21	395,653	17,309	691,720	6,179	9,081	4,200	1,199	102	37,762	944	7,969	847
1892	467	14	148	5	379,899	16,146	685,591	5,142	8,765	4,163	1,234	104	41,558	883	13,021	1,399
1893	763	23	419	13	384,710	16,350	697,448	4,800	10,538	4,478	1,227	98	23,883	418	12,211	1,189
1894	758	.....	.....	....	.....	.....	.....	.....	10,774	.....	.....	.....	14,712	....	17,988	.....

(*a*) From *Statistisches Jahrbuch für das Deutche Reich.* (*b*) Not including brass.

The exports shown in the tables below require very little remark. It may be said, however, that the coal and coke exported go to France, Belgium and Austria, while the iron ore is sent principally to Belgium and France. The exports of pig iron showed a considerable increase last year, but have not been growing rapidly, as the policy of the German manufacturers is now, and has always been, to export their production as much as possible in finished form and not as raw material, and this policy has generally proved successful.

MINERAL EXPORTS OF GERMANY. (*a*) (METRIC TONS.) (Unit of value $1000.)

Year.	Aluminum and Nickel Wares.		Cement.		Coal.		Coke.		Copper, Bars and Sheet.		Copper, Manufactured.		Copper, Pig.	
1890....	1,379	$2,241	396.046	$4,320	9,145,187	$28,896	1,074,755	$6,227	2,906	$1,054	8,417	$5,451	8,429	$2,571
1891....	1,417	2,125	388,457	3,816	9,536,374	29,961	1,354,298	7,138	4,145	1,430	9,675	5,992	6,244	1,779
1892....	1,317	1,647	432,153	2,776	8,971,055	24,974	1,717,893	7,295	4,507	1,352	10,076	5,832	6,598	1,666
1893....	1,463	1,475	423,892	2,450	9,677,305	26,150	1,902,424	7,325	4,890	1,350	12,646	7,450	7,497	1,775
1894....	.....	.....	406,369	.....	9,379,075	.....	2,261,961	.....	.....	5,008	.....	.....	6,608	.....

Year.	Gold, Bars and Crude.		Gold, Coined.		Iron Ore.		Iron, Pig.		Iron, Wrought		Iron, Various Kinds of.		Iron and Steel Rails.	
1890....	3	$1,890	14	$8,518	2,208,480	$1,800	116,922	$1,917	142,811	$4,999	116,848	$3,281	130,837	$3,762
1891....	7	4,781	41	25,608	1,984,428	1,501	111,154	1,808	193,253	5,725	176,185	4,230	142,846	3,571
1892....	10.6	7,421	48	30,036	2,276,155	1,711	113,391	1,568	199,064	5,340	185,616	4,046	113,712	2,559
1893....	5.3	3,650	35	21,725	2,353,398	1,750	108,675	1,475	231,297	5,900	c225,902	4,600	87,360	1,850
1894....	....	.....	....	.....	2,558,729	.....	154,647	.....	300,598	.....	.....	.....	.....	.....

Year.	Wire Nails.		Iron, Various Manuf's of.		Kaolin, Feldspar, Fire Clay.		Lead.		Leads, Crayons, and Pastels.		Lead, White; Zinc, White; Zinc, Gray.		Lead, Tin, and Zinc, Manuf's of.		Machinery.	
1890	41,040	$1,898	c390,233	$41,875	59,785	$598	32,124	$2,128	978	$807	21,212	$2,090	5,357	$2,261	88,112	$16,551
1891	49,709	2,051	472,682	45,025	75,396	754	24,971	1,514	943	743	22,128	2,066	5,738	2,261	91,110	17,139
1892	50,323	1,887	450,336	36,975	82,983	829	25,647	1,363	948	711	24,306	2,016	4,271	4,369	916,631	14,418
1893	54,849	2,050	483,484	39,650	79,570	800	23,945	1,175	1,090	817	25,754	19,765	11,825	4,354	96,105	16,076
1894	.....	.....	.....	.....	.....	....	24,354	.....	.....	.....	.....	.....	.....	.....	.....	.....

Year.	Phosphate, Super.		Potash.		Potassium Salts.		Precious Metal Wares.		Salt.		Saltpeter.		Silver, Bars and Crude.	
1890.....	56,253	$1,677	10,628	$1,011	67,658	$2,375	95	$9,040	199,467	$889	10,135	$1.014	.....	.....
1891.....	43,318	1,299	11,094	1,137	76,987	2,700	89	7,825	254,370	985	9,663	1,015	.....	.....
1892.....	56,075	1,402	12,233	1,254	63,242	2,250	85	6,375	197,371	765	8,874	932	352,756	$10,345
1893.....	62,800	1,175	10,865	1,125	85,858	3,050	87	5,975	196,095	825	9,652	925	450,596	11,800
1894.....	60,668	.....	.....	.....	.....	.....	.....	.....	.....	....	.....	.....	.....	.....

Year.	Silver, Coined.		Stone, Rough and Hewn.		Ultramarine.		Zinc. Sheets.		Zinc. Spelter.	
1890	.....	.....	540,908	$2,951	5,258	$763	16,178	$1,982	57,427	$6,389
1891	.....	.....	505,574	2,748	4,404	639	15,370	1,979	57,852	6,581
1892	37,613	$992	537,220	2,675	4,353	631	16,304	1,875	53,287	5,529
1893	29,434	694	483,103	2,416	4,142	601	17,459	1,669	62,592	5,455

(*a*) From *Statistisches Jahrbuch für das Deutsche Reich*, 1892, 1893 and 1894. The classification in the issues of 1892 and 1893 differ. Also from *Vierteljahrshefte zur Statistik des Deutschen Reichs*, Part II., 1893, and Part II., 1894. (4 marks = $1.) (*b*) Including scrap-iron, structural-iron, blooms, ingots, etc. (*c*) Including manufactures.

GREECE.

THE mineral industry of Greece was fully described by Mr. E. Grohmann in THE MINERAL INDUSTRY, Vol. II., and very little is to be added beyond the statistics for the year just closed. In the following tables will be found the mineral production of Greece for the five years from 1890 to 1894, inclusive, those for the years preceding 1890 having been given in the article above referred to.

MINERAL PRODUCTION OF GREECE. (*a*) (IN METRIC TONS.) (1 drachma = 20 cents.)

Year.	Blende.		Calamine, Calcined.		Chrome Ore.		Emery.		Gypsum.		Iron Ore.		Iron Ore, Manganiferous.	
1890..	2,310	$84,220	32,850	$1,056,800	800	$9,600	.....	.....	98	$1,764	90,470	$113,088	126,620	$329,240
1891..	2,870	102,440	25,800	811,200	200	2,400	936	$18,720	100	1,800	76,350	96,200	108,733	262,486
1892..	2,800	75,160	24,769	624,160	1,470	17,934	1,479	19,227	110	1,800	142,445	185,178	157,756	371,190
1893..	2,727	47,480	19,862	385,300	1,820	20,800	2,449	31,837	133	2,180	67,670	81,200	121,352	281,540
1894..	1,030	16,700	19,800	348,480	1,477	18,400	3,570	46,410	85	1,540	121,570	142,100	159,080	314,120

Year.	Soft Lead.		Lead Ore, Argentiferous.		Lead, Argentiferous.		Lead Dust.		Lignite.		Magnesite.		Manganese Ore	
1890.....	....	.....	3,250	$159,380	13,787	$1,441,600	2,549	$25,400	8,500	$17,000	8,734	$27,949	13,547	$93,474
1891.....	....	.....	3,946	154,683	14,528	1,462,970	1,900	19,000	10,700	21,400	5,223	15,669	13,453	86,099
1892.....	....	.....	2,380	74,720	15,958	1,410,780	1,129	9,800	11,500	23,000	10,100	28,400	11,716	84,120
1893.....	....	.....	4,625	97,122	14,534	1,156,900	1,913	17,800	12,134	24,268	8,815	24,680	5,250	36,760
1894.....	479	$24,910	6,250	147,500	13,955	1,073,500	1,680	13,700	14,320	28,640	13,262	59,340	9,319	52,190

Year.	Millstone, No.		Puzzolan.		Sea Salt. (*b*)		Sulphur.	
1890..	.....	$6,000	44,284	$39,855	18,000	$288,000	2,044	$65,020
1891..	.....	5,200	34,727	31,248	19,772	316,352	1,498	46,120
1892..	.....	5,200	30,800	27,720	21,600	345,600	1,664	46,592
1893..	.....	8,000	32,348	29,100	18,329	293,264	2,400	67,380
1894..	11,448	5,535	28,550	25,700	21,310	332,436	1,528	35,755

(*a*) The figures for 1890–93, inclusive, furnished by Mr. E. Grohmann of Seriphos. The figures for gypsum, lignite, millstones, puzzolan, salt, and sulphur are the sale returns. The figures for all the other substances are the quantities exported. Of substances not included in the above there were sold: Silver, 1890, 200 kilos, $6000; soft lead, 1890, 27 tons, $1700; 1892, 76 tons, $4370. Exported: Copper ore, 1890, 150 tons, $5250; magnesia bricks, 1893, 1275 tons, $25,500. (*b*) Government monopoly.

Upon the whole the year was not unfavorable to the industries of the country, and in nearly all branches an increase is shown in production over 1893. The most important articles in value are the lead and zinc ores from the Laurium mines. These mines continued active throughout the year, a portion of the output coming from the slag heaps, for the working of which concentrating

works were erected in 1893. The zinc ore from these mines shows a considerable falling off in the quantity of blende produced, but the calamine was about the same in quantity as in the previous year. A slight falling off in the amount of lead smelted was due mainly to the somewhat lower grade of the ores found during the year. The Laurium Company increased slightly its net profits owing to the better course of exchange which made it possible to dispose of the products on better terms.

The ancient iron mines of Seriphos, which have been worked ever since the Roman times, still continue to be productive. The output both of iron ores and of manganiferous iron ores was largely increased in 1894. This iron ore is all exported, and finds a ready market from its excellent quality and low percentage of phosphorus. In former years a considerable quantity of Greek ore was sent to the United States, but since 1892 there have been no shipments of that kind.

The production of manganese ore, which in 1893 fell off largely, in 1894 recovered nearly to the average of preceding years. The producers, however, have suffered from the increased competition of the Russian ores.

The exports of emery from Naxos are steadily increasing, and showed last year a gain of some 45%. The quality of the Naxos emery has long been known and this ore commands the highest price; although of recent years it has had to compete with the cheaper emery from Asia Minor, its superior purity has enabled it to hold the market. The emery mined in this island contains before cleaning some 70% of corundum, a higher proportion than is found in any other deposit.

Another item of some importance in the mineral production is magnesite. The use of this mineral in modern metallurgical operations is extending, and as it is of comparatively rare occurrence in a condition pure enough to make it commercially valuable, the Greek deposits are assuming additional importance. The only other magnesite ores which compete with them are those of Styria in Australia, and the newer deposits of California, which are still only partially developed and but little worked. The Greek ore is fully equal in quality to the Styrian and can be somewhat more cheaply produced. The works for the manufacture of magnesite brick for furnaces which were established some two years ago on the island of Eubœa have continued in successful operation, and it is claimed are turning out brick of high refractory quality.

The production of sulphur is not increasing, and the amount exported last year was only 1528 net tons. It is not probable that this output can be much exceeded, as the deposits are comparatively limited.

Greece has only a small supply of mineral fuel. No true coal is known to exist, and the only fuel produced is a brown coal or lignite found in Thessaly. The working of this is being extended gradually and the total production amounted to 14,320 tons in 1894. It is perhaps owing to this scarcity of fuel that the metallurgical industries of the country are comparatively limited.

Nothing further has been done with the silver ore deposits of the island of Milo, and the government has not been successful in finding any one to accept the contract for working these mines which was proposed two years ago. The ore deposits are very extensive, but of so low a grade that their working would not pay, especially at the present price of silver.

ITALY.

THE mineral production of Italy is of considerable extent and variety; it was treated at much length in Vol. II. of THE MINERAL INDUSTRY, and is referred to elsewhere in this volume under the heads of the different substances.

While there has been no important change in the amount of the production, much progress has been made in recent years in the introduction of improved machinery and better methods of mining, in the ventilation of mines and in the condition of the miners and other workmen employed. In this respect much good has resulted from the legislation of recent years.

Iron ore is produced in small quantities only, though several deposits of iron ores exist and are worked to a limited extent. The chief reason for the comparatively slow development of the iron and other metallurgical industries has been the high cost of fuel, nearly all of which is imported. The country has no true coal; its only mineral fuel is lignite, or brown coal.

Of the minerals produced several are of importance. Asphaltum is mined and exported, and the borax production supplies a large part of the European demand. There are valuable deposits of alunite also. A small quantity of petroleum is produced, though the value of this product is limited.

The most important mineral industry of the country, the production of sulphur, is not at present in a flourishing condition. This is due to several causes, one of which is the fall in prices due to competition and to the increasing use of pyrites in the manufacture of sulphuric acid, which has resulted in modifying greatly the position of sulphur in the principal markets.

The chief cause, however, is found in the condition of the producers. The volcanic deposits of Sicily, which furnished most of the supply, are almost entirely owned by small proprietors, who have not the capital to introduce new methods, even if they had the intelligence to desire them. The laborers employed in the mines generally receive very low wages and are in a miserable condition. The reduction due to falling prices two years ago caused strikes and riots, the effects of which are still felt.

Efforts have been made to combine the producers with a view to bettering the situation; but there are many difficulties in the way, and success seems yet distant.

MINERAL PRODUCTION OF ITALY. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Alum.		Alunite.		Antimony Ore.		Asphaltum.		Boracic Acid.		Copper Ore.		Gold Ore.		Graphite.	
1890	1,290	$26,276	5,000	$5,500	891	$65,742	45,125	$240,778	2,824	$301,424	50,378	$371,541	8,296	$104,320	1,735	$4,656
1891	1,029	20,080	4,000	3,840	891	65,742	28,180	135,780	3,831	444,780	53,059	565,867	7,729	93,276	2,415	6,593
1892	1,695	36,050	4,000	3,840	621	45,672	34,580	168,184	2,560	321,910	102,427	552,288	6,612	94,696	1,650	3,778
1893	.....	.....	4,200	4,031	1,193	40,402	25,980	113,160	2,847	313,170	96,299	509,509	7,393	132,746	1,465	3,080

Year.	Iron Ore.		Iron Pyrites.		Lead Ore.		Lignite.		Manganese Ore.		Manganiferous Iron Ore.		Mercury.	
1890	220,702	$483,203	14,755	$37,719	32,187	$1,301,539	376,326	$581,254	2,147	$10,414	.....	.....	449	$583,994
1891	216,486	553,437	19,868	54,118	30,233	1,196,846	289,286	441,170	2,429	12,919	.....	.....	330	356,400
1892	214,487	554,431	27,670	71,987	33,310	1,139,098	295,713	426,073	1,243	8,359	4,622	$8,320	325	305,500
1893	191,305	356,539	29,460	72,227	29,004	813,107	317,249	454,300	810	6,548	8,805	14,960	273	264,737

Year.	Petroleum.		Salt, Rock.		Salt, Saline.		Silver Ore.		Sulphur.		Zinc Ore.	
1890.....	417	$24,121	17,099	$51,660	9,879	$67,799	1,750	$420,195	369,239	$5,653,058	110,926	$2,450,529
1891.....	1,131	68,420	31,285	75,890	9,258	53.390	2,006	394,697	395,528	8,905.091	120,685	2,544,121
1892.....	2,548	150,900	15,504	49,619	8,217	38,455	1,680	345,898	418,535	7,844,333	129,731	2.722,099
1893.....	2,652	159,010	16,790	56,910	8,602	39,810	1,236	235,594	417,671	5,923,335	132,767	2,093,415

METALLURGICAL AND REFINED PRODUCTS OF ITALY. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Antimony.		Asphaltum.		Boracic Acid.		Borax.		Briquettes.		Copper.	
1890....	182	$54,716	10,302	$80,594	1,874	$187,400	950	$114,000	576,050	$3,664,740	6,406	$2,504,365
1891....	218	37,714	9,375	66,020	1,775	177.500	2,056	267,280	644,005	4,099,570	5,977	2,243.229
1892....	315	53,822	9,270	78,570	1,089	130,680	1,471	191,230	612,069	3,883,650	6,039	2,159,469
1893....	376	59,560	8,905	65,711	2,847	313,170	1,099	104,287	540,790	3,273,730	6,911	2,386,247

Year.	Gold, Kilos.		Iron, Pig.		Iron, Wrought.		Lead.		Petroleum, Benzine, etc., Refined.	
1890.....	206	$108,836	14,346	$425,784	176,374	$9,769,728	17,768	$1,137,152	350	$42,000
1891.....	284	166,839	11,930	315,209	152,668	7,996.459	18,500	1.139,600	813	74,448
1892.....	330	204,579	12,729	411,258	124,273	6,278,691	22,000	1,144,000	1,573	154,495
1893.....	362	224,203	8,038	230,921	138,046	6,826,843	19,898	994,300	2,613	258,676

Year.	Salt, Sea.		Silver, Kilos.		Steel.		Sulphate of Alumina.		Sulphur, Refined.	
1890.....	442,010	$899,851	34,248	$1,164,432	107,676	$5,821,481	2,553	$58,430	105,660	$2,213,171
1891.....	347,274	613,555	37,600	1,203,200	75,925	3,948,766	859	17,108	154,611	4,393,278
1892.....	395,269	800,831	43,000	1,281,400	56,543	2,756,499	1,890	40,450	182,630	4,595,280
1893.....	397,506	929,522	40,095	1,130,679	71,380	3,397,426	2,050	43,878	34,750	641,902

MINERAL IMPORTS OF ITALY. (*a*) (METRIC TONS.)

Year.	Coal. (*c*)	Iron, Scrap.	Iron and Steel. (*d*)	Machinery.	Marble, Alab'ster R'gh.	Marble, W'kd	Ores, Various.	Sulphur
1890	4,354,847	168 043	101,284	31,651	476	277	6,607	28
1891	3,916,685	137,233	80,488	23,077	296	266	7,346	20
1892	3.877,571	145,723	80,889	22,392	216	379	16,497	50
1893	3,724,401	176,978	86,190	21,403	550	245	49,267	25

MINERAL EXPORTS OF ITALY. (*b*) (METRIC TONS.)

Year.	Coal. (*b*)	Iron, Scrap	Iron and Steel. (*d*)	Machinery.	Marble and Alab'ster	Marble M'f's.	Ores, Various.	Sulphur.
1890	7,098	59	889	1,189	68,820	58,313	286,889	328,708
1891	13,322	143	576	1,104	69,474	53.958	327,326	269,377
1892	12,919	256	683	1,076	*77,816	57,917	272,278	291,081
1893	12,655	198	1,501	1,429	72,887	56,447	307,685	310,867

(*a*) From the *Revista del Servicio Minerario*, and the metallurgical production for 1893 from "*Zeitschrift für Berg- und Hüttenwesen*, 1894, p. 509. (*b*) The zinc ore exports were in 1890, 80,759; 1891, 104,656; 1892, 119,286; 1893, 113,218 tons. The iron ore exports were in 1890, 186,676; 1891, 202,309; 1892, 124,755; 1893, 156,273 tons. The lead ore exports were in 1890, 8266; 1891, 7328; 1892, 6695; 1893, 5561 tons. The copper ore exports were in 1890, 9894; 1891, 10,116; 1892, 12,719; 1893, 12,811 tons. (*c*) All kinds of fuel. (*d*) Pig and wrought.

JAPAN.

THE ancient mineral industry of Japan has now substantially disappeared, and the modern system, in which the mines are worked and their products treated under approved methods and with machinery of the latest pattern, has taken its place. In mining, as in many other industries, the Japanese have taken up quickly and intelligently the improvements made in other countries, and have adapted them to their own purposes. The change in methods, which was begun a number of years ago under charge of foreign engineers, has been carried forward by the Japanese engineers and managers with much success, and with careful adaptation to the special peculiarities of the country. The Japanese workmen are generally good miners and ready to learn, and they adopt new methods with but little difficulty.

The accompanying tables show the mineral production of Japan from 1890 to the latest attainable dates; the statistics for the years prior to 1890 may be found in THE MINERAL INDUSTRY, Vols. I. and II.:

MINERAL PRODUCTION OF JAPAN. (*a*) (IN METRIC TONS; 1 YEN = $1.)

Year.	Alum.	Antimony.	Arsenic.	Asphalt.	Coal. (*c*)	Copper.	Copper Sulphate.	Copperas.	Gold, Kilos.	Graphite.
1890..	112	*b*1,895	0.289	4,685	2,643,074	18,259	374	949	735.03	4,574
1891..	5	*b*2,268	0.008	5,143	3,214,883	19,730	376	569	701.31	2,464
1892..	.....	*b*1,386	1.025	.....	3,207,805	20,796	63	.....	669.96	601
1893..	.....	1,649	3	.....	3,328,879	18,034	.....	766	737.69	3

Year.	Iron.	Lead.	Manganese.	Petroleum, Refined Liters.	Quartz, Crystal.	Silver, Kilos.	Salt.	Sulphur.	Tin.
1890.....	22,451	776	2,596	*h*2,048,731	4,279	52,996	632,673	20,741	48
1891.....	18,529	803	3,229	*h*2,384,370	8,878	58,785	715,978	21,963	44
1892.....	*g*19,791	889	5,027	2,461,149	.....	59,610	735,141	*i*20,521	41
1893.....	17,781	1,115	14,169	15,087,325	.....	69,381	.....	23,927	38

(*a*) *The Mining Industry of Japan*, Tokio, 1893, and *Resumé Statistique de l'Empire du Japon*, 1894. Figures for calendar year 1893 have been furnished by the Mining Bureau, Tokio. The reports from the government mines, which produce only gold, silver, copper, copper sulphate, iron and coal, are published for fiscal years ending March 31; those from private mines are for calendar years. In 1892 the production also included 2268 tons of iron pyrites.

(*b*) Including in 1890, 1798 tons sulphide; 1891, 2131 tons sulphide; 1892, 42 tons metal, 1341 tons sulphide, and 1431 tons ore.

(*c*) Including in 1890, lignite 19,031 tons; in 1891, 15,119 tons.

The imports and exports since 1890 are given in the tables below. The more important of the exports are coal, copper and sulphur. The chief imports in value are iron, steel and petroleum.

MINERAL IMPORTS AND EXPORTS OF JAPAN. (IN METRIC TONS.)

IMPORTS. (*a*)

Year.	Brass.		Coal.		Iron.		Kerosene.	Lead.		Nickel.		Quicksilver.	
1890.....	6	$2,947	11,587	$110,497	10,512	$185,948	$4,950,256	971	$85,425	85	$118,423	64	$102,833
1891.....	9	48,238	15,110	142,918	12,387	199,209	4,535,720	1,221	104,028	9	9,651	70	105,660
1892.....	243	204,405	.....	.....	*b* 62,313	3,740,219	.....	*c*7,077	759,033	.....	.....	66	95,546
1893.....	163	67,471	7,517	81,707	98,944	4,301,400	4,401,401	3,547	331,868	42	60,761	76	115,082

IMPORTS—*Continued.*					EXPORTS. (*d*)							
Year.	Tin.		Zinc.		Antimony.		Coal.		Copper.		Sulphur.	
1890....	127	$69,281	546	$69,716	1,716	$349,961	1,234,127	$4,796,090	19,567	$5,352,314	18,801	$263,283
1891....	128	71,721	336	42,762	1,859	232,499	1,259,782	4,749,734	17,464	4,877,090	19,149	284,831
1892....	104	62,984	.....	.....	1,229	163,309	1,300,068	4,577,106	18,013	4,870,501	.....	.....
1893....	142	90,578	3,065	462,690	1,316	183,854	1,519,888	4,817,913	15,364	4,574,709	10,441	238,833

(*a*) In 1893 were imported: Coke, 5105 tons, $29,325; copper, 3 tons, $1478; German silver, 46 tons, $38,290; graphite, 2 tons, $232; iron manufactures, $1,090,122; various metal manufactures, $255,679.
(*b*) Includes manufactures of iron and steel. (*c*) Includes sheet and pipe.
(*d*) Exported in 1892 and not on table: Minerals, 61,288 kilos, $110,131; lead, 48 tons, $419; brass and brass wire, 49.96 tons, $73,013; copper, sheet and wire, 9.47 tons, $31,680; iron manufactures, $44,806; bronze manufactures, $213,522; sundry manufactures, $43,007. In 1893 also exported: Bronze, 416 tons, $91,115; Coke, 1143 tons, $7219; various metal manufactures, $162,324; miscellaneous minerals, $217,086.

During the year 1894 there was no occurrence of special importance in the mining history of the country. The greatest increase in production was made in the output of coal. The extension of railroad facilities, the adoption of machinery and the cheapness of labor have combined to enable the Japanese operators not only to increase the production of coal to a point considerably beyond the home demand, but also to introduce it in the markets of the East in successful competition with the English and Australian coal, with which those markets have heretofore been supplied.

The copper mines of Japan, of which the Ashio is the most important, are increasing their output slightly. The same may be said of the lead mines, although the quantity of the last-named metal is not large as yet. The production of manganese ore is growing steadily, and exports are also increasing, a considerable amount having been sent last year to the United States. The iron industry promises a considerable growth, although much remains to be done in this production. The government is encouraging the production of iron as much as possible, and its intention of establishing steel works on a large scale was announced some time ago.

Exploration of the petroleum deposits was continued, but no new developments of importance are to be noted during the year. A careful geological examination of the oil-producing districts is now in progress. The production is already large enough to supply a considerable portion of the home demand, and the quality of the Japanese petroleum is said to be excellent.

MEXICO.

THE chief mineral industries of Mexico—silver, gold, copper and quicksilver—are fully referred to, and the figures of production given in the articles on those subjects, so that very little need be added here. Mexico continues to be the second silver producer in the world, and the output of that metal has been well maintained, in spite of its lower price. The copper production is increasing, chiefly owing to the development of the great Boleo mine.

The iron industry is not growing, and work at the important iron deposits in Durango and elsewhere proceeds slowly, chiefly on account of the high cost of fuel.

Perhaps the most important work now in progress is the development of the coal deposits which is now in progress at several points. For the economical working of the Mexican mines a cheaper supply of fuel is the most important requisite and that can best be secured from the coal veins known to exist in Coahuila and other States of the Republic.

The mineral production of Mexico will be found in the articles above referred to; the imports and exports are given in the following tables:

MINERAL IMPORTS OF MEXICO. (*a*) (METRIC TONS AND MEXICAN DOLLARS.)

Year. (*b*)	Coal.		Coke.		Copper.		Iron and Steel.		Lime and Cement.		Marble.	
1888..	104,542	$730,786	In. under coal.		297	$206,690	5,063	$591.755	913	$15,424	22	$854
1889..	153,111	1,135,082	"	"	924	593,166	85,318	3,247,940	13,914	168,812	1,304	51,610
1890..	209,788	1,497,793	"	"	1,230	705,768	92,509	4,112,906	18,285	177,918	639	15,295
1891..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1892..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1893..	254,610	1,356,666	62,386	$315,327	688	529,175	57,233	3,071,824	9,662	140,251	245	8,862
1894..	162,613	626,070	71,619	378,522	659	462,985	43,128	2,496,000	4,066	28,664	152	8,099

Year. (*b*)	Petroleum.		Quicksilver.		Soda, Caustic.		Sulphur		Sulphate of Copper	
1888....	11,028	$264,683	572	$465,418	429	$27,665	130	$4,616	1,002	$73,329
1889....	16,520	484,010	708	638,075	2,085	324,335	556	17,056	1,076	74,929
1890....	18,087	498,940	1,040	982,302	3,301	154,935	628	18,603	1,139	89,888
1891 (*c*).	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1892 (*c*).	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1893....	22,404	370,674	727	603,525	834	52,085	898	18,996	1,442	82,500
1894....	16,061	242,027	711	506,643	1,982	113,137	234	8,878	858	66,901

(*a*) From the *Boletin Semestral de la Direccion General de Estadistica and the Estadistica Fiscal.*
(*b*) Fiscal years, ending 30th of June.
(*c*) No official figures have been published for the fiscal years 1890–91 and 1891–92, as we are informed by the *Secretaria de Fomento.*

MINERAL EXPORTS OF MEXICO. (*a*) (IN KILOGRAMS.)

Year. (*b*)	Gold and Silver.	Copper, Metallic.		Copper Ore.		Lead.		Tin.	
1881	$19,256,744	.....	$68,788	.....	.....	.....	$25,868	.....	.....
1882	17,064,789	.....	3,245	.....	$41,288	.....	57,953	.....	.....
1883	29,628,628	.....	4,106	.....	61,890	.....	47,554	.....	.....
1884	33,553,157	.....	4,287	.....	35,010	.....	183,469	.....	.....
1885	33,763,852	.....	14,660	.....	28,100	.....	329,239	.....	.....
1886	29,906,401	.....	2,330	.....	.....	.....	485,948	.....	.....
1887	33,560,502	.....	37,560	.....	.....	.....	323,205	.....	.....
1888	.....	3,048,416	615,666	.....	.....	3,393,611	382,236	.....	.....
1889	38,785,275	5,273,664	817,989	75,873	13,775	4,205,260	467,737	.....	.....
1890	38,621,290	5,299,190	735,183	38,511	1,857	5,613,952	607,329	.....	.....
1891	36,256,372	5,364,871	940,920	33,600	850	8,138,194	1,125,468	.....	.....
1892	49,137,304	4,348,702	860,378	123,901	8,937	10,676,548	2,363,521	.....	.....
1893	56,504,305	12,820,282	2,265,881	435,685	11,512	1,418,976	345,646	2,862	$1,420
1894	46,484,360	11,516,382	1,979,728	2,877,321	65,441	1,146	100	58,416	13,231

Year. (*b*)	Coal.		Marble.		Guano.	
1881	.....	$320	.....	$3,080	.....	.....
1882	.....	10	.....	5,455	.....	.....
1883	.....	3,650	.....	8,014	.....	.....
1884	.....	760	.....	4,925	.....	.....
1885	.....	70,436	.....	14,369	.....	.....
1886	.....	247,348	.....	8,198	.....	.....
1887	.....	12,434	.....	15,314	.....	.....
1888	402,243	2,177	825,451	35,917	4,810,449	$68,024
1889	83,552,558	350,170	948,206	51,530	2,168,818	35,362
1890	45,149,962	188,507	2,256,461	162,134	2,271,076	28,025
1891	39,482,132	160,702	1,111,612	87,556	1,492,047	29,000
1892	55,969,921	221,154	1,400,355	169,654	.....	.....
1893	8,279,968	33,960	3,367,591	349,233	559,936	12,021
1894	49,729,184	205,605	1,039,841	108,512	.....	.....

(*a*) From the *Annuario de la Estadistica*, 1894.
(*b*) Fiscal years ending June 30.

RUSSIA.

By F. Theis.

The mineral industry of Russia, although it dates back some 200 years, has had a very slow development; many of the reasons for this are given in treating of the different metals below. The chief causes can, however, be expressed in a few words; the great extent of the country; the fact that railroads have penetrated into only a few districts until recent years; the severity of the climate, which makes the season of navigation on the rivers and watercourses comparatively short; the fact that the supplies of mineral fuel, although large, are for the most part situated at long distances from the deposits of iron ore and other minerals; finally, and chiefly perhaps, the fact that the Russians have always been primarily an agricultural people, but little given to concentrating in cities and to manufacturing industries. This last cause is certainly the most important, and it is a fact that the concentration of capital in industrial enterprises and the growth of cities, which have been such marked features of the present century in western Europe and in the United States, have as yet had comparatively small influence in Russia.

Notwithstanding this slow development, in certain branches of the mineral industry Russia holds a very important place. While the iron industry is still limited in extent, the excellence of the Russian iron has long been noted. The cast iron of the Oural region is unequaled in quality anywhere else in the world, and the steel of the South Russian works is noted for its excellence. As a gold producer Russia has held a high rank for a number of years; prior to the discovery of the South African mines the country held the third rank, being exceeded only by the United States and Australia; although the large production of the Transvaal has placed it second or third on the list of gold producers, Russia remains the fourth, and is steadily increasing its output of the yellow metal. In other branches of the mineral industry also its growth is now increasing rapidly, and with the extension of its railroad system there is no doubt that its growth will continue.

The different branches of the mineral industry in Russia are treated below in alphabetical order:

Asbestos.—This mineral was first mined in Russia in 1889, in the Ourals (government of Perm). The output in 1889 was 30.3 tons; in 1891 it was 323 tons; in 1892 it had increased to 1184 tons, showing a considerable development.

Coal.—Coal is mined in Russia as follows:

I. In European Russia: 1. In the region of the Donetz (government of Ekaterinoslav). 2. In Poland (government of Petrikau). 3. In the Ourals (government of Perm). 4. In the Moscow district (governments of Tula, Rjasan and Kaluga). 5. In the Kiev district (government of Yelisavetgrad). 6. In Turkestan (governments of Samarkand, Ferghana and Syr-Darya). 7. In the Caucasus (governments of Kutaïs and the Kuban district).

II. In Asiatic Russia: 1. In the district of Kuznetzk, of the government of Tomsk. 2. In the coast region. 3. On the island of Sakhalin (or Saghalien as the older, but less correct spelling is). 4. In the Kirghiz Steppe.

Up to the year 1855 coal mining was carried on only in Poland and in the southern part of Russia, the total output amounting to about 164,000 tons yearly. Later on, the government endeavored to introduce coal mining in other parts of the empire also, notably in the Ourals, in the Caucasus, and in Siberia. At present the Donetz region has the largest output. This region borders on the northeast on the government of Ekaterinoslav; on the south on the government of Charkov; on the west on the government of Woronesk. It furnishes several kinds of mineral coal, including anthracite, bituminous or free-burning coal and gas-coal. The coal measures of this region are reckoned among the richest in the world. Next in importance and amount of output comes Poland, particularly as a producer of brown coal or lignite. The Donetz basin and Poland together produce approximately 90% of the total coal output of Russia. Among the other coal districts the government of Perm in the Ourals is most prominent in its production, though the government of Moscow also ranks high as a producer of coal and lignite. In Asiatic Russia very little coal is mined as yet, although extensive coal measures are known to exist. The coal fields in the Kuznetzk basin in the government of Tomsk, between the Ssalairsk Mountains and the Altai, cover an area of approximately 5600 square kilometers. In the governments of Irkutsk and Yenisseisk, coal measures are to be found in the valleys of the Angara and of the Yenissei, in the basins of the Irkut and the Bolaya, as well as in the lower Tunguska Valley. At a distance of about 250 kilometers from Irkutsk there have been lately discovered large deposits of coal and lignite. The Transbaikal region, which up to the present day has been only partially explored, is also known to contain coal measures. It is evident that Siberia is rich in coal deposits, which later generations will utilize.

The output of mineral coal in Russia amounted in 1892 to 6,922,910 tons. In 1892 there were imported 1,600,000 tons, and exported about 12,000 tons of coal. This would make the consumption of coal in the country 8,510,910 tons. If we deduct from this figure 48,000 tons, representing the output of Asiatic Russia, the amount of coal consumed is equal to about 94 kilograms per capita. If we compare this figure with the corresponding data in other countries we find that this consumption is very low, but it should not be forgotten that large parts of even European Russia are only thinly populated, and that wood and liquid fuel (petroleum residues) are used in many places as fuel in all branches of manufacturing, on the railroads and on steamers.

Copper.—The richest copper deposits occur in the Ourals and in the Caucasus, where the region between Batoum and Kars is said to be rich in extensive deposits.

Copper is also produced in the Altai Mountains and in the Kirghiz Steppe in Siberia, and in Finland. Over 50% of the total output comes from the Ourals. The second place is occupied by the Caucasus, while Finland and the Altai Mountains rank nearly together as copper producers. The production of the Kirghiz Steppe is at present insignificant. During 1892 the total number of copper smelting works in Russia was 25. In 1893 a total of 122,239 tons of ore were smelted, yielding 5010 tons of copper. The output has decreased from 5458 tons of copper in 1891. On the other hand the imports of copper have increased.

If we consider that the output of copper amounted in the year 1868 to 4455 tons, it is evident that, notwithstanding the rich ore deposits in the Ourals and in the Caucasus, the copper production of Russia has made no progress. The largest output was reached in the year 1884, amounting to 6219 tons. The imports have been as follows in metric tons:

IMPORTS OF COPPER INTO RUSSIA.

1884	4,816	1887	832	1890	4,305
1885	3,800	1888	554	1891	5,327
1886	2,195	1889	3,970	1892	6,240

The exports are insignificant, amounting to only 88 tons in 1890, and 90 tons in 1891.

Cobalt Ore.—Cobalt ore is produced only from the mines of the Siemens Brothers at Daschkassan, in the vicinity of Yelisvetpol, Caucasus. In 1892 19,000 kilos of ore were obtained.

Chrome Iron Ore.—This ore is obtained from localities on the eastern slope of the Oural Mountains. It occurs also on the western declivity, generally associated with deposits of serpentine. In 1892 only 1392 tons were produced, which was a decrease of 1705 tons from the production of the preceeding year. Rich ores contain 60% chromic oxide. On an average the ores contain 53% chromic oxide. The greater part of the ores is utilized in the chemical manufactory of Uschakov in Yelabuga in the manufacture of chrome steel. The production has decreased considerably in recent years, having been in 1888, 7222 tons; in 1889, 4166 tons; in 1890, 2370 tons; and in 1891, 3097 tons.

Gold.—Deposits of gold occur in Russia:

I. In European Russia: 1. In the Ourals, in the governments of Perm and Orenburg. 2. In Finland, in Finnish Lapland, government of Uleaborg.

II. In Asiatic Russia: 1. In Western Siberia, in the governments of Semipalatinsk and Akmolinsk. 2. In Eastern Siberia, in the governments of Yenisseisk, Irkutsk, the Transbaikal and Yakutsk. 3. In the Amour region and in the Pacific Coast district, both of which are considered as parts of Eastern Siberia.

Deposits of gold were worked as long ago as 1732 in the Archangel government. In 1875 placers were worked in the Caucasus along the river Damblud, but only for a short time, as the returns were poor. Prospecting in other parts of Russia has not been successful. The greater part of the gold in Russia has been obtained from placer working.

Taking an average for a long period, about 7% of the total gold output of

Russia was obtained by vein mining, and 93% by placer mining. The greater part of the gold which is obtained from deep level or vein mines comes from the Ourals, 86% being from that district and 14% from Siberia. The quartz veins usually occur in slate or in granite. Gold deposits occur in metamorphic rocks, chiefly in the neighborhood of plutonic dikes.

The total gold production of Russia from 1745, the beginning of gold mining operations, has been derived from the following sources: 27.6% from the Ourals; 6.4% from Western Siberia; 66% from Eastern Siberia, including the Amour region; 0.01% from Finland. It will be seen that Eastern Siberia is by far the most important source of supply.

During the period from 1814 to 1820 only the deposits of the middle region of the Ourals, chiefly placer mines, were worked. In the year 1830 the gold production of the Ourals was 92% of the total gold output of Russia. The northern part of the Ourals has not proved rich in gold, and the center of production has gradually moved toward the south, as the deposits of the middle region were exhausted. Some of these southern deposits show at present an increasing production; most of them, however, particularly those of Miask, in the government of Orenburg, which were formerly very prolific, show a decided decrease. Although the Ourals still contribute the larger part of the gold obtained from vein mining, no continuous development of this kind is noticeable. For this condition of affairs the impoverishment of the upper strata, lack of skilled mining engineers and want of enterprise may be mentioned as reasons. The auriferous veins, particularly in the deeper levels, frequently contain the gold in combination with pyrites, and it can be profitably extracted only by chemical methods. At present there are on the Ourals only three mills which use such methods of gold extraction. According to the last report issued the gold output of the Ourals has increased, amounting to 12,352 kilos in 1892. The assay value of the ore treated has, however, decreased; within the last few years it has averaged 2.4 to 3 oz. per ton. The richest ore found assayed about 21 oz. to the ton. In the placer mines of the Ourals the sand assayed on the average 0.35 to 0.45 oz. to the ton. Within the past few years the methods of placer mining in the Ourals have been improved.

The gold deposits of Finland are situated in a locality whose climate and topography are unfavorable to mining. The first gold was mined in 1870 in the valleys of the Tanaelf and Ivalojoki Rivers, the yield being 19 kilos of the metal. The largest output was reached in 1871 with 56.6 kilos; in 1892 the output amounted to only 10 kilos. These fluctuations are due chiefly to the uneven distribution of the gold in the sand. The latter has to be frequently dug out of rock fissures, necessitating complicated machinery, the motive power being either horses or water. The highest assay these sands showed amounted to 1.4 oz. per ton.

The placer deposits of Western Siberia were first worked toward the end of the thirties. The largest quantity of gold—1630 to 1650 kilos per annum—is obtained in the Altai Mountains. The total gold output of West Siberia, in the governments of Semipalatinsk and Akmolinsk, amounted in 1892 to 2790 kilos; in 1893 to 2795 kilos. The placer sands assayed on the average 0.24 to 0.30 oz. per ton. Generally it can be said the gold output of Western Siberia has increased during recent years.

The gold which is mined in Eastern Siberia, including the region of the Amour and the Coast district, is obtained from alluvial deposits. In Nertschinsk some gold is obtained in smelting silver ores. The chief producers are Olekma-Vitimsk and Kirensk, in the government of Irkutsk, in the Lena River system, and the districts of Yenisseisk, Nertschinsk, and of the Amour; next in order of importance are the regions of Atchinsk, Minussinsk, Kainsk and Nishne-Oudinsk, while the other gold deposits of Eastern Siberia influence the total production but slightly. The richest placer mines, not only of Eastern Siberia but of Russia generally, are situated in the Lena River system at Olekma-Vitimsk. Among these the Ivanovski, Piedteschenski and Leonov placers are the most noted. The output of the Olekma-Vitimsk placers at its highest point reached 15,380 kilos (unrefined) gold per annum. Since 1882 the output has considerably decreased and now reaches only 8200 to 9200 kilos a year. Notwithstanding this decrease the gold deposits of this region must be considered as the richest in Russia. In the Yenisseisk region the annual output amounted in the forties to as much as 19,000 kilos. To-day this figure has fallen to nearly 3500 kilos. In the seventies the attention of prospectors was turned more and more to the Amour region. The output there has continuously increased, and amounts to approximately 8000 kilos a year.

The average annual gold output of Eastern Siberia, including the Amour and the Pacific Coast, amounted during the last 10 years to 24,600 kilos. The average assay value of the Eastern Siberia placer deposits is steadily decreasing. According to the last annual report assays of sand from the various deposits gave assay results as follows: Yenisseisk, 0.24 oz. per ton; Yakutsk, 1.82 oz.; Transbaikal, 0.44 oz.; Amour, 1.30 oz.; Littoral (Coast), 0.40 oz.

The total production of Russia amounted in 1892 to 42,604 kilos of unrefined gold. Of this quantity the Ourals furnished 12,352 kilos; Western Siberia, 2790 kilos; Eastern Siberia, 27,452 kilos; Finland, 10 kilos. In 1892 the production was 43,001 kilos.

The statistical data from the gold output in the Ourals, in Western and Eastern Siberia, show that the gold contents of the sands are decreasing in almost all the placer mines. The placer deposits of Eastern Siberia in the government of Yakutsk, particularly those of Olekma-Vitimsk, yielded up to the beginning of the eighties sands showing on the average an increasing assay value, and even to-day the gold contents of the sands from these placers are high—1.8 or 1.9 oz. per ton; but the other deposits of Siberia show a decrease in gold values, and many of them—for example those of the Yenisseisk district—show signs of considerable exhaustion. Nevertheless it appears from the statistical data that the gold output is increasing on the whole. The exhaustion of one deposit is counteracted by the opening up of new and rich mines. As a rule, when the production of the richer mines of a district passes its climax, mining is extended to the poorer deposits; thus a larger quantity of sand is washed over a larger area, and consequently the total output of the district may grow, although the average productiveness of the placers decreases. The discovery of new gold fields in Siberia does not appear impossible, particularly as the deposits in the Amour and the Pacific Coast region have been but partially explored; further it is often the case that mining operations are resumed in deposits which were formerly con-

sidered too poor to pay. The greatest increase in Russian gold production may be expected through scientific mining, and from the results of geological exploration and the application of improved machinery. The opening of the Siberian Railroad will decrease the cost of labor and supplies, and will help to increase the gold production both by promoting the settlement and exploration of the country and by extending largely the area of the placers which can be profitably worked.

Graphite.—Deposits of graphite of great magnitude are known to exist on the Tunguska and Yenissei Rivers in Siberia. The amount of these deposits has been estimated as high as 1,750,000 tons from present explorations. The production thus far has been insignificant, only 16 tons having been mined in 1890; 164 tons in 1891, and 82 tons in 1892.

Iron.—The iron-producing regions of Russia rank according to their importance as follows: 1. The Ourals. 2. The southern and southwestern part of Russia. 3. Poland. 4. The Moscow district. 5. Finland. 6. Siberia. 7. The northern part of Russia. 8. The Caucasus. During the last year 1,960,000 tons of iron ores were mined.

The following governments are named in the order of their output of pig iron: 1. Perm (Ourals). 2. Ekaterinoslav (southwestern Russia). 3. Petrikau (Poland). 4. Oufa. 5. Radom. 6. Nischne-Novgorod. 7. Orenburg. 8. Kaluga. 9. Wjatka. 10. Vladimir. 11. Kuopio. 12. Don. The output of pig iron already has reached 1,000,000 tons.

In the production of wrought iron the district of the Ourals, with the governments of Perm, Oufa and Orenburg, occupy the first places. An average taken from the returns of 10 years shows that the Ourals can claim 60% of the total output. Next in importance are the manufacturing districts of Poland, the district of Moscow, the northern portion of Russia, Finland and Siberia.

As far as steel production is concerned the first place is occupied by the manufacturing districts of Southern Russia, in the government of Ekaterinoslav, where steel production has considerably increased; this district has about 35% of the total output. Then follow according to their importance the district of Moscow, the northern part of Russia, Poland, the Ourals, Finland and Siberia.

The first iron mine in Russia was opened in 1699, during the reign of Peter the Great, by Nicolai Demidoff. The Demidoffs, whose descendants own to this day important iron works, are therefore considered as the founders of the iron industry in Russia, which did not exist until the beginning of the eighteenth century, at a time when in other European countries it had already reached a high degree of development. For many decades the Ourals remained the only mining district of Russia; the task of introducing mining in other parts of the country remained for later generations. In studying the statistical data one necessarily comes to the conclusion that the iron industry has developed slowly and has to show at present only a moderate success. An explanation for this may be found in the great distances between the ore deposits of the Ourals and the coal measures of South Russia, which furnish the proper kind of coal for the smelting of iron ores; in the short season when cheap transportation by water is available; in the small development of the railroad system, and also in the lack of skilled workingmen. Although within the last 20 years coal deposits

have been discovered in the Ourals, and in South Russia, and there are in the neighborhood of the Donetz coal basin rich iron mines; although new railroad lines have been built and the waterways improved, while the skill of the workingmen has advanced, it is still probable that some years may elapse before Russia will be able to supply home demands.

Owing chiefly to the cost of obtaining coal and to the extent of forest land existing in several of the iron mining districts, the proportion of furnaces using charcoal as fuel is large in Russia.

The largest imports of pig iron are received through the Baltic ports. The government steel works at St. Petersburg and the steel works in Poland obtain most of their supplies of raw iron in this way, though some also comes from Germany by rail. An important center of demand is Batoum, which is in part supplied from the Oural furnaces and in part draws from abroad, the foreign iron being brought by the Black Sea.

Iron Pyrites.—Iron pyrites are found in the Oural Mountains, and in the coal of the Moscow region; also in the government of Novgorod, near Borovitschi, where the people find it in the beds of the Meta and other rivers at low-water level. Iron pyrites are also obtained in the copper mines of the Altai Mountains. In the year 1892 altogether about 17,561 tons were produced.

Lead.—Lead is obtained in Russia chiefly from argentiferous ores, and as a by-product of silver. The greatest production is in the Altai Mountains in Siberia, though even there the quantity has decreased considerably from that of former years, since the ore obtained from the greater depths gives a correspondingly smaller yield of lead. The remaining districts where lead is produced are in the vicinity of Nertschinsk and Semipalatinsk in Siberia and of Alagir in the Caucasus. In the year 1890 there were 930 metric tons of lead produced. The production in recent years has been variable. For a long time the quantity has not been sufficient to supply the domestic requirements, and this deficiency is covered by imports from foreign countries. The imports in 1892 amounted to 21,000 tons.

Manganese Ores.—Manganese ores are mined in the following districts: 1. In the Caucasus in the district of Sharopansk in the government of Kutaïs. 2. In the government of Ekaterinoslav. 3. In the Oural, in the governments of Orenburg and Perm. The center of the manganese industry is in Sharopansk in the government of Kutaïs. The ore deposits extend over an area of about 144 square kilometers and are considered as the most prolific manganese occurrences in Russia. The output in 1879 amounted to 871 tons, and since then it has steadily increased. The ore deposits are situated in a very mountainous and inaccessible stretch of country along the river Koirili, at an altitude of 700 to 1050 ft. above the village of Chiatur. The roads which lead from the mines to the village are dangerous and difficult, and the ore has to be transported in small quantities on mules. In bad weather accidents are so frequent that transportation has to be stopped almost entirely, and consequently the development of the industry is slow. The ore, as might be expected, is mined in a primitive and wasteful manner. Only in a few mines of wealthier owners have levels been explored and worked according to ordinary practice. Even in the better class of mines the loss of ore is very considerable. Skilled labor is scarce, and only a few of the

workingmen can be relied on for eight months in the year. The ore, if well prepared, contains 83% to 87% peroxide when dried at 212° F., and never more than 0.10% phosphorus; it has thus 54% to 55% metallic contents. It is believed that the prospects for the industry are excellent, and a branch railroad for the transportation of ore from Chiatur to Sharopansk has been completed. In the government of Kutaïs alone 185,000 tons of manganese ores have been mined, according to the latest report. Almost the whole output has been exported. England imports much of the manganese which is needed for the steel industry from the Caucasus. The total output of manganese amounted in 1893 to 199,195 tons. The exports were in 1889, 52,896 tons; in 1891, 74,730 tons; in 1892, 131,965 tons.

Nickel Ore.—Nickel ore has been discovered in the government of Daghestan, in the region of the Caspian Sea in the Caucasus. The Russian sources of information contain no statement concerning the production. It is reported, that, by the direction of the Russian Department of Mining, the deposits of nickel ore discovered in the Oural Mountains have undergone a thorough geological examination, and the working of the deposits in the future will depend on the results of this investigation.

Petroleum.—The chief center of the Russian petroleum industry is in the town of Baku and the surrounding peninsula, which extends into the Caspian Sea, and is called Apsheron. Petroleum has been also found in (*a*) the Kuban region in the northwestern part of the Caucasus; (*b*) the Terek region, north of the city of Vladikavkas; (*c*) the government of Tiflis in the southern part of the Caucasus; (*d*) the government of Yelizavetpol, on the Armenian-Persian frontier; (*e*) Daghestan and Ferghana on the Caspian Sea; (*f*) Tauria, north of the Crimea; and (*g*) in the Transcaspian region.

The total output of the localities named, outside of the Apsheron peninsula, amounts to from 30,000 to 32,000 tons per annum and is insignificant, as compared with that of Baku. Only in the Terek region do the prospects for the naphtha industry appear promising.

The petroleum output on the Apsheron peninsula is the important part of the industry. The wells are located north of the city of Baku on the Balachani plateau, near Romanin, and also south of the city, near Bibi-Eybat. Without considering the losses at the wells and the quantity of petroleum which has been consumed in and around Baku, the output was for two years, in metric tons:

	1892.	1893.
From pumping wells	3,450,000	3,530,000
From flowing wells	1,240,000	1,790,000
Total	4,690,000	5,320,000

Losses at the wells in 1893 have been estimated at 196,560 tons. The amount of oil reported from flowing wells was obtained from 38 wells.

The refining of the oil was carried on during 1893 in 114 works, of which number 90 prepared illuminating oils; 14 illuminating and lubricating oils; 6 made lubricating oils only; 2 made benzine and light oils, and 2 prepared

asphalt. In these works there were reported in all 948 stills for illuminating oils, 186 stills for lubricating oils, and 12 stills for benzine and light oils.

For the storage of petroleum from the wells there were provided at the close of 1892 in all 325 reservoirs in or about Baku, their total capacity being estimated at 1,647,611 tons. Of these reservoirs 96, with a total capacity of 1,363,000 tons, were simply pits dug out of the soil and rock; 188, with a total capacity of 274,275 tons, were built of masonry, while the remaining 41, containing 10,336 tons, were iron tanks. From this it will be seen that the iron tanks which are in universal use in America for storing oil are but little used in Russia.

At the close of 1893 there were in the Batoum district 472 wells, while 102 new wells were under the drill.

The statistics of the refineries for 1893 as compared with 1892 are given in the table below, in metric tons:

Year.	Crude Oil Treated, Tons.	Illuminating Oil Produced, Tons.	Tons Crude Oil to One Ton Refined.
1892.....	4,207,562	1,290,537	3.29
1893.....	4,754,304	1,396,519	3.41

The sales reported for the two years were as follows, in metric tons:

Year.	Illuminating Oils.	Lubricating Oils.	Residuum.	Crude Oil.	Other Products.	Totals.
1892.....	1,286,174	95,151	1,920,604	190,417	5,635	3,497,981
1893.....	1,402,685	102,096	2,351,170	199,754	11,322	4,067,027

The exports of illuminating oils from the district amounted to 832,760 metric tons in 1892 and increased to 888,485 tons in 1893. The oil from the district is shipped on three lines. First, on the Caspian Sea to Astrakhan, and thence chiefly by steamer on the Volga and other rivers to interior points in Russia. Second, to Transcaspian ports, from which it is carried to Persia and Central Asia, and lastly to the port of Batoum, from which the oils are shipped to southwestern Russia, to Europe and to eastern ports. The shipments to the Black Sea port are made entirely in tank cars which are loaded direct at the works, the refineries being connected with the railroad by switches, or else furnished with pipe lines by means of which the oil is carried to the railroad. There has been for several years a promise that the railroad facilities should be supplemented by a pipe line extending to the Black Sea, but this has not yet been carried out. The oil shipments to the ports on the Caspian Sea are made in tank steamers for the most part, only the oil intended for Persia being exported in cases or barrels. The oil intended for Eastern Russia is carried to Astrakhan in tank steamers, but as the Volga, for a number of miles above that port, is too shallow for seagoing vessels, it is transferred from the steamers to river boats which are built for the most part especially for this traffic. At Samara and other ports on the Volga the oil is transferred again from these river steamers to tank cars on the railroads, shipments being made in this way to nearly all the large towns in Russia and even to the seaports on the Baltic.

Up to a few years ago the oil wells of the regions in the Caucasus have been little considered owing to the large production of the Apsheron peninsula, but since the fear that the oil wells of Baku may give out in a not too distant future has gained ground, the attention of some oil producers has been devoted to the regions which have been known to possess oil-bearing strata, but which have been neglected owing to the want of transportation. Recently, in the northern part of the Caucasus, oil wells of considerable importance have been sunk not far from the city of Grosnoje in the Terek region. How prolific these wells are may be judged from the fact that from a bore-hole 120 meters deep 4900 tons of naphtha were thrown up within 24 hours. The strength of the flow was so great that a portion of the derrick was destroyed.

Since the harbor of Petrovsk has been connected by means of a railroad with the town of Vladikavkas, the wells of Grosnoje are in direct connection with the Caspian Sea, with the valley of the Volga, with the South Russian markets by way of Rostov on the Don, and with the Black Sea by way of Novorossisk. The Rostov-Vladikavkas Railroad has decided to use naphtha residues on its lines instead of coal. A pipe line has been established from the wells near Grosnoje to the railroad. The demand for naphtha residues as fuel has increased since the Grosnoje wells have been opened up, not only along the railroad line to Rostov but also in the town of Rostov itself. The flour mills of that city alone have used 32,760 tons of residuum. The manufacturing districts northwest of Rostov up to Charkov have begun to adopt residuum as fuel, the Grosnoje wells being the center of supply.

According to Russian sources a pipe line is projected to extend along the coast of the Caspian Sea from Baku to Petrovsk. The latter place has direct railroad communication with the European portion of Russia.

According to the *Engineer Dreier*, a high authority on the trade, the total output of petroleum from the wells, including all the districts in the Caspian region, and including also the oil lost and wasted and the oil consumed at and near the wells, was 4,918,000 tons in 1892 and 5,400,000 tons in 1893.

Platinum.—Platinum is found in Russia only in the Ourals in the government of Perm. Occasionally some platinum is obtained with gold from the gold placers. Approximately 1,350,000 tons of platinum-bearing sands were subjected to the process of washing in 1892. The sands contained on the average 3.5 grams platinum per ton. In 1892 the output of crude platinum amounted to 4570 kilos; in 1890 to 2845 kilos, and in 1891 to 4236 kilos.

The refining of the crude platinum has been carried on by the Tenteleva Chemical Works, near St. Petersburg, and in the laboratory of Kolbe & Lindfors in St. Petersburg. The discovery of platinum in the Ourals dates back to 1819. The mining of the metal, however, was only begun in 1824. Since that time approximately 113,211 kilos of platinum have been mined. The largest output was reached in 1892. Of other metals of the platinum group in the same year 24.5 kilos of osmium and iridium were obtained.

Quicksilver.—Deposits of cinnabar are known to exist in Russia in the Oural regions, in the Caucasus, in the southern part of the government of Ekaterinoslav and in Eastern Siberia. In the Ourals masses of cinnabar weighing as much as 1 lb. are found in gold-bearing sands. In the year 1759, in East Siberia on

the right bank of the Ssernyi-Yldikan River, limestone containing a sprinkling of cinnabar was discovered, and this product was extracted up to the year 1848. At the present time the inhabitants of Yakutsk are said to use this cinnabar for medicine. As yet the cinnabar deposits of the government of Ekaterinoslav are not utilized for the production of quicksilver.

Toward the end of the year 1886 the first quicksilver manufactory in Russia was opened. This is owned by the Auerbach Company and is situated near Nikitovka, a station on the Kursk-Charkov-Azov Railroad. Since 1889 Russia has begun to export quicksilver, especially to Hamburg. The exports in some of the last few years have amounted to 300 tons; in 1889 to 128 tons; in 1890 to 227 tons; in 1891 to 286 tons; in 1892 to 300 tons. For 1892 the production of ore was 66,907 metric tons.

Silver.—Paying silver deposits occur: 1. In the government of Tomsk, in the Altai Mountains. 2. In the Transbaikal, in the Nertschinsk district. 3. In the Kirghiz Steppe, in the Semipalatinsk district. 4. In the Terek region, in the Caucasus. 5. In Finland, in the government of Vyborg.

The smelting works of the Altai Mountains can be considered the chief producers of Siberian Russia. The decrease or increase of the total yearly silver production is influenced by their output. In Finland some silver is obtained in the copper smelting works at Pitkaranta. During the year 1892 there were 36,500 tons of argentiferous ores smelted, yielding 10,000 kilos of unrefined silver.

Tin.—In Russia tin is produced only in Finland, in the government of Vyborg, from the mine at Pitkaranta. Tin ore is obtained there in connection with copper ore, and has to be separated from it. The production is small. In 1892 there were 1750 tons of ore obtained, from which about 9500 kilos of refined tin was extracted. The production shows a decrease in contrast with former years. At present the domestic requirements have to be met by imports from foreign countries. The imports amounted in 1888 to 2354 tons; in 1889 to 2189 tons; in 1890 to 2644 tons; in 1891 to 2700 tons; in 1892 to 2830 tons.

Zinc.—The zinc production of Russia is limited to the kingdom of Poland. In 1892 there were 59,954 tons of of zinc ores mined and 4374 tons of zinc were produced. In 1893 the output increased to 60,200 tons of zinc ore and 4600 tons of zinc. In 1874 the output of zinc amounted to 4095 tons; the increase is hardly perceptible. The reason for this is to be found in the great depth of the ore deposits and in the resulting high cost of mining. The Polish ores are said to be much purer than those of Silesia; nevertheless the cost of production in Silesia is much lower. The imports of zinc, which in 1887 amounted to about 20% of the domestic output, have increased with each year.

The Mineral Resources of Siberia.

While it has long been known in a general way that the extensive region lying between the Altai on the south and the Arctic Ocean on the north, and extending from the Oural Mountains to the Japanese Sea, contained most valuable resources in the form of mineral deposits, very little indeed has been done toward their development, and no systematic geological examination of the country had been undertaken until about three years ago. After the commencement of

work on the Siberian Railroad, special attention was called to the country which was likely to become a feeder to the new line, and in addition to the labors of the civil engineers connected with the railroad the government detailed a number of geologists and mining engineers who were attached to the railroad staff, and who had a special commission to investigate the mineral resources of the country. The notes given below are summarized from the reports and papers submitted by these engineers. In many cases the data obtained related to different districts, and are interwoven in such a way that it is difficult to separate them, but they have been arranged below in order as far as it is possible.

Coal.—The governments of Tomsk, Irkutsk, Yenisseisk, the district of Akmolinsk and the Kirghiz Steppe are known to abound in coal. In Tomsk the principal coal measures so far as explored are in the Kuznetzk basin, lying between the Altai and the lower range of the Ssalairsk, and covering a region estimated at 560 square kilometers. Extending through the governments of Irkutsk and Yenisseisk are coal measures outcropping at different points in the valleys of the Yenissei and the Angara, in the basins of the upper Irkut and the Bolaya, as well as in the lower valley of the Tungouska. The field most carefully examined lies about 250 kilometers from Irkutsk. The Transbaikal shows in several of its river valleys outcrops indicating the existence of large coal measures, but they have been so far but little explored. In Eastern Siberia, in the Amour region, coal was first found not far from the town of Vladivostok. In 1888 a special examination of this deposit was made by the navy department with a view to obtaining a coal supply for the Russian fleet on the Pacific. Mines have been opened and exploration is being carried on with success. On the island of Sakhalin coal deposits have been explored, but are not yet worked to any extent; upon occasion they can be used to supplement the naval supply from the mines already mentioned. In the Transbaikal, also, a large deposit of brown coal or lignite has been discovered some 30 kilometers from Krasnoyarsk, in the neighborhood of Kamakovo, but nothing has so far been done. Notwithstanding the large resources so far referred to, very little has been done in new mining. The output of Siberia for four years is given in the following table, in metric tons:

	1890.	1891.	1892.	1893.
Kuznetzk district	17,226	18,814	18,900	.....
Amour district and Sakhalin	14,627	17,864	17,600	.....
Kirghiz Steppe	2,076	1,114	1,500	.....
Total	33,929	37,792	38,000	39,160

Much reliance has been placed for fuel supplies upon the forests of Siberia, but notwithstanding the immense forest growth which covers a large part of the Transbaikal, the region of the headwaters of the Amour and of the Lena and the valleys of the Angara, Yenissei and other rivers, it is noticed that the supply of wood is gradually decreasing, chiefly because of the forest fires which yearly destroy an immense number of trees. These forest fires are started usually from the campfires of hunters, smugglers and shepherds, and by the nomadic tribes

which still occupy a large part of the country. It is evident that the supply of coal will be a most important item in considering the future value of the great central railroad and the cost of operating it. It may be added that the geological explorations actually in progress are being conducted with special reference to the supply of fuel.

Copper.—This metal is mined and smelted in Siberia only in the government works. As the ore occurs usually at considerable depth, whereby the cost of mining is increased, private enterprise has participated very little so far in the copper industry in Siberia. Such enterprises as have been started have always failed owing to lack of capital or bad management. The copper production of Siberia is therefore small. The total output in 1890 was only 317 tons; in 1891 it was 239 tons, and in 1892 it was 310 tons.

Gold.—In the preceding article on Russia it has been already stated that Siberia furnishes the larger part of the gold output of the country. The principal deposits of the yellow metal in Western Siberia are found in the governments of Tomsk and Irkutsk; in Eastern Siberia, in the governments of Yenisseisk and Yakutsk, in the Transbaikal, in the Amour country, and in nearly all the river valleys along the Pacific coast. With very few exceptions the gold of Siberia is obtained by placer mining. The placers are generally worked in a primitive way, very few places being found where operations are conducted according to modern methods, or under the guidance of geological examination. For instance, the removal of the overburden or valueless strata covering the gold gravels, the handling of the gravels themselves, and the removal of the tailings are generally effected with no other tools than the pick and shovel and the old-fashioned Russian two-wheeled cart. Only a very few of the larger working mines are provided with steam-power; water-power is generally used, as this is found almost everywhere, the gold regions of Siberia existing in a country of enormous and rapid streams.

The usual method of working is to remove the overburden of gravel, sand and clay, then to cart the auriferous gravel to the washers. The machine most generally used is an iron reservoir with a perforated bottom which acts as a sieve, the stream of water carrying the finer particles through the perforations, the larger gravel and stones remaining in the iron reservoir. The finer sands are usually carried by a current of water through an inclined wooden sluice, then through a pile of brushwood, and finally over coarse blankets. The brushwood and the blankets together collect the heavier constituents, such as gold, pyrites, etc., while the lighter sands are carried back into the river or dumped elsewhere as tailings. The brushwood and blankets are cleaned up at intervals and the coarse gold separated. It will be seen that this is a very wasteful method of working, which may save part of the coarse gold but will certainly leave the finer and lighter metal in the tailings.

When the gold is separated, the usual custom is to have it weighed by the superintendent and transferred to the custody of a military guard which is generally not far distant. When a sufficient quantity of gold has accumulated at any point it is sent under a military escort to the nearest town where an assay office is located; it is there cast into ingots and sent to the mint at St. Petersburg. The local mint office issues to the operator depositing gold a draft upon

the St. Petersburg mint for a corresponding amount of coin. All gold found has to be deposited or turned over to the government authorities in this way.

In cases where the overburden is too thick for economical removal shafts are sunk to the gravel. In the placers on the headwaters of the Lena in the Yakutsk government and the Oleminsk district, the soil is perpetually frozen; in the short summer it thaws out for a few feet from the surface, but below that it must be displaced by powder and dynamite.

In many Siberian placers the custom prevails of paying the miners not by time, but by the quantity of gold delivered, which is there reckoned in solotnik (4.265 grams). This system leads inevitably to a great deal of waste, the hope of the men being simply to secure the largest amount of gold possible in a given time, and not to attempt to save the finer gold, which usually requires more time in operation. Wherever this system is followed it is certain that a large proportion of the precious metal goes into the tailings and the deposits are quickly exhausted. This so-called "solotnik" system also prevails in several places where rock and vein mining for gold is carried on. In most of these places the mines are not provided with machinery, the prevailing method being to pick the ore out by hand, select the pieces of ore, crush them in a hand mill and then pan out in a wooden rocker or cradle. Under this system nearly 50% of the contents of the ore are lost.

Most of the gold deposits in Siberia are worked by private enterprise. Under the system now prevailing it is customary for companies or associations of individuals to locate and lease as many claims as possible. The result of this has been that large areas of ground are frequently held by a few persons who do not operate them. In Eastern Siberia, where the population is small and there is little opportunity for individual enterprise, a great number of claims have been located by large companies, some of which are operated and others held for the future. In this way the opportunity for the individual prospector has been almost entirely destroyed. The center of gold production in Siberia during the last fifty years has moved gradually eastward as new deposits were opened and the old claims exhausted, or at least work upon some of them no longer paid under the present system.

According to the last annual report the average yield of gold from one (metric) ton of auriferous gravel amounted in West Siberia to from 0.8 to 1.0 gram; in Eastern Siberia to from 0.8 to 6.20 grams; in the district of Olekma-Vitimsk one ton of auriferous gravel yielded on an average 6.20 grams; in the Amour region, 4.30 grams; in the coast district, 1.35 gram, while the highest yield was 14.406 grams gold from one ton.

If we follow the statistical data concerning the gold production of Russia, we see that, notwithstanding the exhaustion of the gold deposits in many regions of Siberia, there has been an increase of the total output. An explanation of this may be found in the circumstance that the falling off in the production of certain localities is counterbalanced by new mining operations on richer fields. If we consider at the same time that the gold production of Russia started on the Ourals, moved continuously eastward, and that the eastern gold fields almost invariably have been the more prolific ones, the increase of the total output, notwithstanding the abandonment of a large number of mines, becomes intelligible.

The primitive methods of mining, the system of "solotnik work," and the deficiencies in the laws regulating the acquisition of gold mining claims are great obstacles in the way of the further development of the gold production of Siberia. In view of this the Department of Mines in St. Petersburg is endeavoring to introduce improved machinery for the purpose of recovering the placer gold; moreover, the chlorination method is to be tried. It is also proposed to revise the laws relating to the acquisition of mining claims, and to prohibit the "solotnik work" system. The general introduction of machinery, at least in all the larger placer mines, is hardly to be expected before the Siberian Railroad is in running order, because at present the transportation of machinery and apparatus is conducted with great difficulties and at a high cost; and the domestic industry is not in a condition as yet to carry out any important or difficult repairs.

Iron.—At the present time the iron works owned by the government utilize almost exclusively the deposits of hematite and limonite, which have been known for a long time; they seldom attempt the working of new deposits. The natives conduct mining in a primitive manner only in the ores of the upper strata of various clay deposits. In these attempts the presence of iron ores is frequently disclosed, to which, however, no further attention has been paid. In fact data concerning the occurrence of iron ores in Siberia are very imperfect. More thorough geological explorations have been recently carried out, mostly in the neighborhood of the government mines. On the basis of these explorations it can be assumed that deposits of hematite and limonite with 60% to 70% of iron occur in the mountainous portions of Siberia. In the plains sphairosiderite has been found in pockets; but these ores have been as yet very little investigated, notwithstanding the fact that they deserve the greatest attention, as the specimens obtained are free from injurious constituents, such as sulphur and phosphorus. Magnetic iron ore has not been found up to the present day; on the other hand chrome iron ore has been found; lumps of specular ore of a considerable size and very rich in metallic iron have also been found in a level of a mine in the Altai Mountains. The few blast furnaces in Siberia, which are conducted at present by private enterprise, use water-power and furnish inferior metal. The works of the government are in a better condition; still there is a great deal of room for improvement. According to the recent reports the iron output has been as follows, in metric tons:

	1890.	1891.	1892.
Iron ores mined.....	12,478	16,812	17,000
Pig iron made.....	7,181	8,409	8,920
Wrought iron made.....	4,338	4,664	5,400
Steel.....	21	31	38

As the output of the government blast furnaces is exclusively used in the manufactories and mines of the government very little of the Siberian iron is available for generable use. Consequently it is necessary to import the iron needed in Siberia from the Ourals, and not infrequently from the western governments. Not much improvement is to be expected until transportation facilities are provided.

Salt.—The salt production of Siberia has not been sufficient up to this time to cover the home demand; at the same time the rich salt deposits in the governments of Irkutsk, Yenisseisk, Tomsk and Tobolsk, as well as in the Kirghiz Steppe, which has been called the "Salt Empire," would permit the export of salt in large quantities were they worked on a considerable scale.

Silver.—The principal silver districts are located in the Altai Mountains, in the government of Tomsk, in the district of Nertschinsk, and around Semipalatinsk. Silver mines have been also discovered in the partly explored Amour region and in the eastern coast districts. In the government of Yenisseisk silver mines were worked in the last century. In the southern part of the Altai, not far from the Mongolian frontier, an exposure of argentiferous lead sulphide occurs with a long outcrop. Mongols who pass the frontier and fur-hunters make use of this ore for casting bullets for their rifles. That this ore must have been known to the Mongols for many years is surmised from the many furnace-like holes found in the earth in this region, generally with metalliferous slags. Samples of this ore were brought in many years ago by gold prospectors, but notwithstanding the high percentage of silver, no mining operations were undertaken. Deposits of argentiferous lead sulphide have been also discovered at Gendebal, in the district of Werchojansk, in the government of Yakutsk, but not utilized owing to lack of fuel. The aboriginal Yakuts used this ore in a similar way to the Mongols on the frontier. Since coal has been discovered in the neighborhood of these deposits mining and smelting operations have been started.

According to the available data mining and smelting operations have been conducted in an unsatisfactory manner for nearly a century in the old government mines of Ssalairsk, Syrjansk and Nertschinsk. Nothwithstanding the fact that these old mines have to contend with difficulties and that the cost of mining is increasing, no serious prospecting operations for the purpose of finding new ore deposits are carried on. Still all the indications point to the existence of such deposits in many portions of Siberia.

Some years ago private citizens suggested that the tailings from the placer mines might be worked to some extent by the silver smelters, but no action has been taken on this suggestion.

According to the latest available report (Kulibin, "Statistics of the Mining Industry in Russia"), the output of silver in Siberia has been as follows, in kilograms:

	1890.	1891.
Altai region	11,159	9,750
Semipalatinsk district	1,191	1,578
Nertchinsk district	899	906
Total	13,249	12,234

This statement gives the raw or unrefined silver. In 1891 there were 685 tons lead smelted.

Summary.—All these facts indicate that this gigantic country possesses extensive mineral resources. With the exception of the gold deposits, they have been in part but very superficially utilized, in greater part not touched at all. They assure the future of Siberian industry when the great railroad is finished.

Mineral Production of Russia.

The following tables give the statistics of Russian production, imports and exports from 1890 to the latest attainable date. The figures for the years prior to 1890 will be found in The Mineral Industry, Vols. I. and II. The most notable feature is the increase of the iron production in recent years.

MINERAL PRODUCTION OF RUSSIA. (*a*) (IN METRIC TONS.)

Year.	Asbestos.	Asphalt.	Chrome Iron Ore.	Clay, Porcelain.	Coal.	Cobalt Ore, Kilos.	Glauber's Salt.	Graphite.	Iron Pyrites.	Manganese Ore.	Petroleum.		
											Crude.	Lighting Oil.	Benzine.
1890	.....	.....	2,370	.....	6,015,145	14,710	.....	16.4	17,147	182,482	3,984,247	1,146,172	2,046
1891	323	140,394	3,097	52,022	6,233,531	9,900	39,320	163.8	18,355	113,090	4,756,417	1,249,592	.....
1892	1,184	17,600	1,392	.....	6,922,910	18,800	.....	82	17,561	199,195	4,207,562	1,290,537	.....
1893	.....	.....	.....	.....	.....	.....	.....	.....	18,120	.....	4,754,304	1,396,519	.....
1894	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Year.	Lubricating Oil.	Phosphates	Salt.	Cobalt	Copper.	Gold, Kilos.	Iron, Pig.	Iron Mfrs.	Lead.	Platinum, Kilos.	Quicksilver.	Silver, Kilos.	Steel.	Sulphur.	Tin.	Zinc
1890	88,026	.....	1,388,365	....	5,732	39,375	684,281	433,210	838	2,845	292	14,567	378,452	161	13	3,774
1891	.....	174,967	1,351,187	99	5,459	39,017	675,000	448,055	558	4,237	324	13,724	433,510	327	9	3,677
1892	95,151	.....	1,361,693	....	5,010	42,604	692,000	494,975	930	4,570	343	10,000	371,199	388	10	4,374
1893	102,096	.....	.....	....	.....	43,000	1,061,582	495,000	.....	.....	367	.....	390,000	.....	10	.....
1894	.....	.....	.....	....	.....	.....	1,200,000	.....	.....	.....	.....	.....	.....	.....	....	.....

MINERAL IMPORTS OF RUSSIA. (IN METRIC TONS; 1 ruble=77c.)

Year.	Cement and Clay		Coal and Coke.		Copper.	Iron.			Lead.	Petroleum.	Salt.	
						Bar and Sheet.	Pig.	Rails.		Lighting Oil.		
1890.....	114,590	$1,096,480	*b*1,542,529	$9,570,330	4,406	96,329	126,332	2,458	21,603	247	17,191	$222,530
1891.....	102,833	974,820	*b*1,540,530	9,267,720	5,327	61,606	75,118	442	18,395	311	13,628	170,940
1892.....	97,149	1,414,854	*b*1,610,000	7,746,465	6,240	.....	.....	.....	26,076	.....	13,121	127,044
1893.....	110,810	.....	1,999,849	8,909,111	13,675	.....	.....	.....	28,697	.....	6,864	75,986
1894.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Year.	Steel, Bar and Sheet.	Sulphur.		Tin.	Zinc.	Soda Potash.	Machinery.	Sulphate of Copper and Zinc.
		Raw.	Refined.					
1890.....	15,087	18,428	465	2,644	5,456	.....	.....	.....
1891.....	10,893	16,017	.....	2,700	.....	.....	.....	.....
1892.....	.....	24,389	.....	2,830	5,680	6,502	43,770	992
1893.....	.....	.....	.....	4,029	8,173	9,696	57,264	1,494
1894.....	.....	.....	.....	.....	.....	.....	.....	.....

MINERAL EXPORTS OF RUSSIA. (IN METRIC TONS; 1 ruble=77c.)

Year.	Coal.	Copper.	Iron and Steel.	Manganese.	Petroleum.					Phosphates.	Platinum.	Potash	Quicksilver.	Salt.
					Crude.	Light'g Oil.	Lubricating Oil.		Residuum.					
							Refined	Unr'fi'd						
1890..	13,672	88	5,001	134,908	12,460	651,387	56,241	18,570	48,917	11,554	.....	.....	.....	.....
1891..	11,178	90	.....	74,730	14,251	739,114	64,799	18,084	51,875	.....	.....	.....	.....	.....
1892..	.....	.....	.....	131,965	4,855	782,587	89,091	12,351	41,753	.....	3.27	606	33	2,981
1893..	.....	.....	.....	125,408	.....	814,311	.....	.....	.....	.....	1.63	425	13	1,523
1894..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

(*a*) Authorities: Russian official figures for 1881–91; Catalogue of the Russian Section at the Chicago Exposition for gold in 1892; Statistics for 1892–93 have been kindly furnished by F. Theiss, Esq., Civil Engineer of Charlottenburg, Germany; obtained in part from official Russian reports and partly from correspondence.
(*b*) Not including coke.

The gold production of Russia is a very important item in its mineral industry. The country ranks fourth in the list of producers, the amount of its output being exceeded only by the United States, Australia and South Africa. Some statistics of this production are given below:

PRODUCTION OF UNREFINED GOLD IN RUSSIA. (c)

Year.	Cabinet of His Imperial Majesty.	East Siberia.	West Siberia.	Oural.	Finland.	Total.
	Kilos.	Kilos.	Kilos.	Kilos.	Kilos.	Kilos.
1890	1,867	24,530	2,432	10,524	16.4	39,369.4
1891	.....	20,377	7,101	11,532	.....	39,017
1892	1,818	27,452	2,790	12,352	10	42,604
1893	.....	.....	.....	.....	.....	43,000

(c) From Catalogue of the Russian Section at the Chicago Exposition, p. 139.

The following estimate of the petroleum production of Russia for the ten years ending with 1893 is from statistics collected by Mr. S. O. Goulishambarov and published recently in the *Russian Journal of Mining;* the figures are in metric tons:

Year.	Tons.	Year.	Tons.	Year.	Tons.	Year.	Tons.	Year.	Tons.
1884	1,477,967	1886	2,457,000	1888	3,154,739	1890	3,979,390	1892	4,904,991
1885	1,900,080	1887	2,702,700	1889	3,310,856	1891	4,750,424	1893	5,544,630

The same authority states that the petroleum deposits recently discovered in the northern part of European Russia, in the district of Petschora, are now being explored. The existence of petroleum there has been known for a long time, but no attempt has been made to work the deposits until now; the oil-bearing territory is on the river Uchta, not far from the Arctic Ocean.

The existence of petroleum in the northern part of the island of Sakhalin, on the Pacific coast of Siberia, has been known for years. Owing to the severity of the climate very little has been done toward developing these deposits, and the output has been very small. Recently oil has been found in the southern part of the island, near Cape Leiden. As the climatic conditions are much more favorable there, it is expected that work will soon be begun on the development of these deposits.

SPAIN.

THE mineral industry of Spain was so fully treated in THE MINERAL INDUSTRY, Vol. II., that we have to add this year only a few remarks regarding changes made in 1894. During the year the industry of the Peninsula was necessarily affected in some degree by the general trade depression which prevailed to a greater or less extent all over the world, and suffered from the further drawback of the increased royalties and other special taxes imposed by the government. Nothwithstanding these drawbacks some progress was made, and in certain lines there has been an increase in the output; but few new mines have been opened, and in several districts, on the other hand, there has been a reduction in the number of men employed and in the general activity. Two of the more important Spanish industries, iron ore and lead mining, are treated of fully in the following pages.

The copper industry has been somewhat discouraged by the low price of the metal, nevertheless it shows but little decrease. The output of the Rio Tinto mines was equivalent to 30,200 tons of fine copper in 1892, and to 31,000 tons in 1893. In 1894 the production again increased, amounting to a total of 32,689 tons of copper, from 1,387,095 tons of pyrites. Tharsis, the next mine in importance, follows very nearly the same course, having produced 10,970 tons of fine copper in 1892 and 11,177 tons in 1893, while its production for 1894 will vary but very slightly from these figures. In the smaller copper mines there has been some decrease, but not to an important amount.

In coal mining there has been substantial progress, as shown by the figures. The tonnage of coal reported for 1894 was 1,776,000 metric tons, an increase over the previous year of 244,000 tons, or about 16%. This was partly due to the fact that improvements have been made at many mines in methods of mining and preparing the coal for the market, so that a sale has been found for it at iron works and elsewhere, in place of imported coal and coke. The domestic sales of the year, it is stated, have varied but little from the average of several preceding years. Some new developments are promised in the coal industry during the current year. In 1894 there was, however, no new work done on the important deposits of lignite discovered in previous years.

In the following tables will be found the production of minerals of various kinds in Spain from about 1890 to the present date, as far as the figures are

obtainable at the present time. The statistics from 1881 to 1890 were given in THE MINERAL INDUSTRY, Vol. II.

MINERAL PRODUCTION OF SPAIN. (*a*) (IN METRIC TONS AND DOLLARS; $1=5 PESETAS.)

Year.	Alum Ore.		Antimony Ore.		Asphalt Rock.		Clay.		Coal.		Cobalt Ore.		Fluorspar.	
1890	.....	.....	820	$25,348	43	$98	5,397	$5,577	1,212,089	$2,424,177	111	$4,368	5	$97
1891	340	$1,700	693	20,805	248	523	180	360	1,262,510	2,525,020	60	1,804	3	54
1892	550	2,750	395	12,467	503	1,051	132	264	*b*1,611,761	3,835,676	.....	.....	2	36
1893	650	3,250	88	2,784	820	1,280	60	30	1,484,794	2,280,720	18	194	56	272
1894	.....	.....	.....	.....	.....	.....	.....	.....	1,776,000	.....	.....	.....	.....	.....

Year.	Copper Ore.						Graphite.		Iron Ore.		Iron Pyrites.		Kaolin.	
	Argentiferous.		Iron, Copper Pyrites.		Copper and Cobalt.									
1890	334	$2,576	3,011,779	$11,058,323	5,077	$121,848	95	$1,064	6,546,495	$7,855,794	163,825	$532,760	1,938	$22,065
1891	.....	.....	3,495,761	13,285,892	3,444	61,361	63	706	5,601,558	6,721,868	283,721	922,662	1,262	13,882
1892	.....	.....	2,731,593	13,111,649	2,080	50,064	34	249	5,236,275	6,283,531	232,162	754,993	500	5,000
1893	15,219	27,901	2,144,908	2,151,603	1,110	26,784	.....	.....	5,419,071	4,056,546	220,000	110,000	1,502	5,397
1894	.....	.....	.....	.....	.....	.....	.....	.....	5,500,000	.....	.....	.....	.....	.....

Year.	Lead Ore.		Lead Ore, Argentiferous.		Lignite.		Manganese Ore.		Mercury Ore.		Phosphates.		Salt.	
1890	161,875	$4,532,995	332,739	$10,146,545	26,307	$42,090	9,872	$98,722	34,580	$1,492,960	48	$96	615,727	$1,813,932
1891	160,418	4,491,712	264,625	8,071,065	27,188	103,500	6,993	6,978	35,169	1,749,583	1,542	3,084	582,833	1,748,498
1892	215,906	5,613,558	192,517	5,852,518	*c*32,870	41,127	16,910	136,171	35,025	1,755,538	2,150	3,152	682,634	2,596,741
1893	169,707	3,263,648	179,458	4,139,695	35,315	41,967	1,460	7,666	34,309	16,018,187	211	415	151,464	85,052
1894	300,000	.....	.....	.....	34,000	.....	.....	.....	.....	.....	.....	.....	520,000	.....

Year.	Silver Ore.		Steatite.		Sulphate of Barium.		Sulphate of Soda.		Sulphur Ore.		Tin Ore.		Topaz of Hinojosa, Kil.		Zinc Ore.	
1890	3,574	$26,029	3,106	$9,693	335	$2,680	332	$1,494	29,639	$76,670	61	$9,255	337	$2,423	81,398	$651,184
1891	15,085	62,189	2,516	10 564	670	5,360	911	4,012	30,577	79,513	69	12,456	1,900	27,654	78,216	651,180
1892	656	113,543	1,341	6,576	665	4,658	350	1,540	26,330	68,458	244	42,347	280	3,173	74,265	530,555
1893	4,825	257,041	4,010	18,705	643	2,943	180	270	24,793	59,830	34	3,611	81	1,874	62,616	387,101
1894	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	51,410	.....

(*a*) From the official *Reports of the Comision Ejecutiva de Estadistica Minera*, Madrid, 1894. The figures for 1894 were kindly furnished by Señor Don Roman Oriol as published in the *Revista Minera*. Other minerals reported: Nickel ore in 1890, 12 tons, $168; in 1892 (including cobalt), 83 tons, value $1250; 1893, 31 tons, value $97; nickel and cobalt, 1893, 38 tons, value $801; lead and copper ore, 1890, 50 tons, value $500; arsenical pyrites, 1892, 10 tons, value $20; 1893, 160 tons, value $324; fossil jet (variety of lignite), 1890, 57 tons, value $5403; 1891, 9 tons, value $810; ocher, 1890, 305 tons, value $2112; 1891, 643 tons, value $1277; 1892, 20 tons, value $117; 1893, 1030 tons, value $710; silica, 1893, 20 tons, value $20; refactory sandstone, 490 tons, value $980; burrionite, 55 tons, value $275; wolfram, 1892, 26 tons, value $1325; 1893, 19 tons, value $975; copper ore, 1894, 48,000 tons; sulphuric acid in fiscal year 1892-93, 885 tons; copper sulphate in 1892-93, 1817 tons, $181.685.

(*b*) Including lignite.

(*c*) Fiscal year 1891-92.

A large part of the ores produced by the Spanish mines is exported in the crude form; nevertheless, there is a considerable metallurgical industry which is growing in spite of some serious drawbacks. The copper produced is mostly exported in ores, or in the form of matte or precipitate. The iron industry, which for some years increased steadily, showed a slight reduction last year in many of its branches. The output of pig iron was nearly the same as in 1892 and 1893, but there was a slight increase in wrought iron, although the latter was offset by a decrease in the manufacture of steel. An effort is being made to cultivate home manufactures with some prospect of success. The chief drawback in this trade is the absence of a supply of good coking coal and the high cost of imported fuel suitable for the iron manufacture. The supplies of ores, as is well known, are large and of excellent quality. The most important single item of metallurgical production is lead, the next in order of value being silver, which is obtained from argentiferous lead ores. The quicksilver mines of Spain have

long been known, as the production of Almaden chiefly has made this country an important factor in the quicksilver trade of the world. The metallurgical production will be found in the following tables:

METALLURGICAL PRODUCTION OF SPAIN. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Alum.		Arsenic Sulphide.		Refined Asphalt.		Hydraulic Cement.		Coke. (*b*)		Copper. (*c*)		Iron, Pig.	
1890....	...	.....	60	$7,541	23	$188	135,988	$388,109	191,235	$772,975	64,373	$9,542,469	170,782	$2,732,634
1891....	...	.....	58	4,753	192	2,531	150,721	423,355	304,030	1,258,407	58,067	8,345,389	159,250	2,002,075
1892....	...	.....	72	4,165	845	10,985	114,428	296,598	354,644	1,493,284	81,343	11,240,821	*d*259,575	7,260,461
1893....	650	$3,250	129	8,262	580	7,540	140,314	356,071	390,110	1,443,544	45,409	4,893,719	134,563	1,878,728

Year.	Iron, Wrought.		Steel.		Lead. (*j*)		Lead, Argentiferous.		Mercury.		Silver, Kilos.	
1890.....	61,445	$2,949,355	75,255	$3,100,491	91,628	$5,611,855	86,325	$8,977,779	1,813	$2,239,547	52,000	$1,770,496
1891.....	64,799	3,110,347	69,902	2,804,468	82,463	5,050,034	76,622	8,427,776	1,790	1,840,108	50,051	1,704,187
1892.....	(*e*)	.....	(*e*)	.....	125,550	6,981,048	93,710	7,297,619	1,657	1,607,579	72,000	2,339,817
1893.....	58,923	2,441,290	76,583	3,048,669	77,456	3,886,695	91,832	7,198,834	1,666	1,394,630	63,605	1,774,671
1894.....	.....	.....	70,000	.....	.....	.....	.....	.....	.....	.....	85,000	.....

Year.	Sulphate of Soda.		Sulphur.		Zinc.					
					Pig.		Sheet.		Calamine, Calcined.	
1890.....	128	$1,536	9,855	$221,737	3,103	$406,780	2,816	$495,040	35,338	$416,441
1891.....	538	6,456	9,900	222,750	2,803	367,154	2,789	490,899	31,379	363,996
1892.....	206	2,204	7,822	132,982	*f* 5,908	.....	(*g*)	.....	28,118	*i*1,211,304
1893.....	247	3,681	4,686	82,600	3,290	405,612	2,462	433,418	*h*21,548	13,963

(*a*) From the official *Reports of the Comision Ejecutiva de Estadistica Minera*, Madrid, 1894. The figures for 1894 were kindly furnished by Señor Don Roman Oriol.
(*b*) Including briquettes, which were in 1890 174,524 tons, value $698,096; 1891, 258,254 tons, value $1,036,192; 1893, 273,118 tons, value $1,117,672.
(*c*) Including precipitate and matte. The precipitate amounted in 1890 to 40,012 tons, value $7,402,140; in 1891, 33,401 tons, value $6,168,502; in 1893, 26,404 tons, value $3,696,628. The matte in 1890 amounted to 24,303 tons, value $2,124,673; in 1891 to 24,444 tons, value $2,116,784; in 1893 to 18,899 tons, value $1,175,956.
(*d*) Including pig iron, wrought iron and steel.
(*e*) Included under iron, pig, 1892.
(*f*) Including ingot and sheet.
(*g*) Included under ingots, 1892.
(*h*) Estimated for the second half.
(*i*) Total value for ingots, sheet and ore.
(*j*) In 1892 contains 99 tons, antimonious lead, value $5963.
Additional substances, 1894: cast iron, 260,000 tons; soft iron, 120,000 tons; mercury, 47,900 flasks; copper precipitate (*cascarade de cobre*, 75% copper), 28,000 tons; copper matte (45% copper), 17,000 tons; zinc, 5700 tons.

Coal and coke form the most considerable item in bulk and in value of the mineral imports, and are followed in order by iron and steel in their manufactured forms. The exports, of course, are the products of the country; iron ore being first, both in bulk and in value, while copper ore, lead ores, iron pyrites and zinc ore all take an important place. The course of the import and export trade can readily be traced in the following tables:

MINERAL IMPORTS OF SPAIN. (*a*) (IN METRIC TONS AND DOLLARS; $1=5 PESETAS.)

Year.	Asphalt and Pitch.		Carbonates, Alkaline.		Chemical Products.	Coal.	Coke.	Coal.	Coke.	Gold Bars, Kilos.		Gold Coin.
1890....	.....	.....	.....	.....	4,555,200	1,718,000		$8,932,000		.....	.....	.....
1891....	36,430	$728,621	23,159	$1,019,037	2,855,200	1,634,400	228,926	$8,825,006	$1,236,002	1,922	$1,191,640	$4,766
1892....	25,682	513,635	23,213	1,109,393	.....	1,688,537	175,872	9,020,169	940,983	7,738	4,797,560	3,936
1893....	33,608	672,164	25,649	1,128,571	.....	1,497,699	267,288	8,014,112	1,410,045	2,203	1,365,860	1,008
1894....	29,639	592,799	26,902	1,143,708	.....	1,612,147	225,900	9,028,019	1,265,046	.....	634,390	.....

Year.	Iron, Pig.		Iron, Bars.		Machinery.		Petroleum, Crude.		Silver Bars, Kilos.		Silver Coin.	Soda Nitrate.	
1890..	.....	.....	.....	.....	32,295	$8,216,600	4,879	$2,229,000	.....	.....	.....	.....	.....
1891..	34,609	$484,533	18,013	$776,996	30,611	7,760,400	54,821	2,192,863	544,901	$21,796,040	$487,916	15,816	$949,007
1892..	30,022	420,312	10,177	478,206	56,297	1,609,381	44,656	1,786,241	97,468	3,898,720	1,000,719	18,335	1,099,917
1893..	23,484	328,784	7,139	343,303	*b*2,795	649,686	54,942	1,977,925	394	14,184	3,827,308	18,998	1,139,923
1894..	26,561	373,885	9,616	417,342	*b*3,134	698,102	44,052	1,263,514	1,935	61,920	4,339,319	23,984	1,439,060

MINERAL IMPORTS OF SPAIN—*Continued.*

Year.	Steel.		Sulphur.		Tin Plate.		Tin Ingots.	
1891	45,002	$1,876,979	7,125	.....	2,659	$265,929	625	$312,867
1892	31,637	1,214,953	8,568	$222,759	2,433	293,341	813	406,580
1893	15,143	717,841	6,330	162,186	2,986	268,794	1,004	395,362
1894	23,121	973,998	5,674	147,531	3,212	254,567	936	459,244

MINERAL EXPORTS OF SPAIN. (*a*) (IN METRIC TONS AND DOLLARS; $1=5 PESETAS.)

Year.	Antimony Ore.		Copper Ore.		Iron Ore.		Iron Pyrites.		Lead-Silver Ore.		Manganese Ore.		Phosphates.	
1890..	596	$35,813	680,271	$5,170,110	5,708,810	$12,559,384	163,825	$327,651	12,952	$993,365	5,570	$52,360	20	$40
1891..	551	33,039	661,762	5,029,398	4,343,887	8,687,768	283,721	567,443	19,405	730,016	3,885	36,520	1,935	3,870
1892..	395	12,467	511,015	3,884,478	4,799,647	8,639,266	443,026	886,052	10,613	890,315	10,410	97,854	1,740	3,480
1893..	87	16,515	574,590	4,391,500	4,646,877	8,564,379	399,880	800,560	12,048	1,016,821	9,480	96,993	.....	.....
1894..	45	2,127	539,290	4,877,801	4,988,222	8,977,400	520,128	1,040,260	12,162	1,020,766	7,319	68,779	.....	.....

Year.	Zinc Ore.		Copper Precipitate.		Iron, Pig, Soft Iron and Steel.		Lead. (*d*)		Quicksilver.		Zinc, Bar, and Sheet. (*e*)	
1890	47,025	$275,841	63,306	$6,149,452	69,218	$1,254,501	140,660	$13,348,710	989	$1,147,364	2,010	$209,074
1891	39,583	238,391	32,270	4,195,221	70,967	1,456,889	146,029	12,386,060	1,886	2,112,159	2,044	212,644
1892	39,574	261,191	36,862	4,768,135	51,975	1,152,324	154,969	10,519,924	1,644	1,840,938	2,161	216,185
1893	32,358	203,372	18,658	3,496,283	31,230	499,693	158,737	10,756,053	1,560	1,746,845	2,486	248,638
1894	34,238	225,200	36,752	*c*4,213,024	48,749	682,112	158,735	11,091,540	870	974,340	2,680	267,999

(*a*) From the *Revista Minera de España* and figures kindly furnished by Señor Roman Oriol, excepting the mineral exports for 1890–92, which are from the *Report of the Comision Ejecutiva de Estadistica Minera*, Madrid, 1894.
(*b*) Engines and boilers only.
(*c*) Includes 35,096 tons matte, $350,970. Other exports: Coal in 1891, 11,460 tons, $61,880; in 1892, 14,300 tons, $77,706; in 1893, 8,387 tons, $45,290; copper matte in 1891, 24,487 tons, $284,055; in 1892, 30,222 tons, $350,591; in 1893, 28,130 tons, $286,302; gold bullion and coin in 1891, $114,576; in 1892, 95,336; in 1893, 114,298; silver bullion and coin in 1890, 25,000 kilos, $1,010,456; in 1891, 101,509 kilos, $4,060,380; in 1892, 2,237,458, $8,349,832; in 1893, 705,703, $254,051; salt in 1892, 232,234 tons, $700,702; in 1893, 200,924 tons, $602,772.
(*d*) Includes argentiferous lead. (*e*) Includes calamine, calcined.

In the following tables are given the production of lead, coal and lignite in Spain for 1894, as estimated from data obtained by Señor Don Roman Oriol. This estimate varies but little from that given in the article on the following pages, and is probably very close to the actual production :

PRODUCTION OF LEAD IN SPAIN BY PROVINCES. (IN METRIC TONS.)

Year.	Almeria.	Badajoz.	Ciudad Real.	Cordoba.	Guipuzcoa.	Jaen.	Malaga.	Murcia.	Total.
1889–90	19,611	.....	.....	17,616	6,385	28,361	2,314	116,895	191,182
1892	18,000	.....	2,000	18,600	5,500	35,000	.....	96,024	175,124
1893	21,000	.....	2,500	19,000	5,500	40,000	.....	100,500	188,500
1894	15,000	.....	.....	17,000	4,000	35,000	.....	80,000	151,000

PRODUCTION OF BITUMINOUS COAL AND LIGNITE IN SPAIN. (IN METRIC TONS.)

Provinces.	Bituminous.		Provinces.	Lignite.	
	1893.	1894.		1893.	1894.
Oviedo	810,000	1,000,000	Guipuzcoa	11,000	.....
Córdoba	310,000	295,000	Barcelona	7,000	8,700
Palencia	149,850	155,000	Baleares	9,000	.....
Sevilla	103,660	127,000	Lérida	4,000	5,900
Ciudad Real	88,000	115,000	Ternel	750	.....
Gerona	40,300	44,000	Gerona	600	.....
León	30,000	40,000	Santander	550	.....
			Logroño	1,200	.....
Total	1,531,810	1,776,000	Total	34,100	

Iron and Lead Mining in Spain.

By Richard W. Barrington.

During the year 1894 the metallurgical and mineral industry of the Peninsula suffered very severely, most especially in the production of lead, iron and manganiferous ores. The serious decline of trade must in large measure be attributed to the heavy increase of taxation on mineral industries. The government, however, at last seems to recognize the necessity of taking some measures to revive the wearied spirits of long-suffering miners, and it is probable that some of the heavy dues will shortly be modified. Taxation has been increased at the following rate:

1. A charge of 2% royalty on the gross output of mines, in place of 1%, as formerly.

2. An increase of 30% on the surface royalty of all mines.

3. A tax on all explosives used for mining purposes of one peseta per kilogram, or nearly 50% on the net value.

4. An export duty of 12.50 pesetas ($2.50) per ton on all lead ore shipped, and of 10 pesetas ($2) per ton on pig-lead.

5. Innumerable stamp and other dues with which the miner and exporter are being continually hampered.

IRON AND MANGANIFEROUS ORES.

Aguilas.—The export of ores during the year 1894 has been 59,962 tons, against 44,600 in 1893; this quantity was, however, nearly all shipped early in the year, and most of the ore was mined during the previous year. Of the various mines at work early in the year in Sierra de Enmedio only one is now in active operation. This district, which for a short period produced a mineral of excellent quality, known in the market as "South Spanish Campanil," is, it is to be feared, past its zenith, and the quantity and quality of the ore are both declining, it being apparent that the deposits in few cases continue for any distance below the surface.

The mines at Pilar and Jarabia, the product of which is known in the market as "Terreros" ore, because shipments were made from Terreros beach before the construction of the Aguilas Railway, still continue working, and ship about 1000 tons per month.

There is some idea of working the rich iron ore deposits situated in Sierra Bacares, as the mines come within reasonable distance of the railway now open to Baza; whether the ore would bear the heavy expense of transportation in the present state of the market is, however, rather doubtful.

Almeria.—Only about 17,000 tons were shipped during the year, which is practically the same as in 1893.

The manganese mines situated near Cabo de Gato have been worked to the extent of 400 tons during the year; but, owing to the powdery nature and high silicious quality of the ore, it does not meet with favor in the market. A cargo from these mines tested in Marseilles gave the following results: Manganese, 37.20%; silica, 24.10%; iron, 4.15%; phosphorus, 0.032%.

It is expected that the various Bilbaino companies which have acquired iron mines in the Province of Almeria will very shortly begin to work their properties. In some of them preliminary work is being pushed on rapidly, and preparations are being made for the construction of railroads, particularly from the Bedar

mines for shipment at Garrucha, and from the Zucainena de las Torres for shipment at Aguas Amargas.

Bilbao.—The export of iron ore from the Province of Vizcaya in 1894 has been 4,298,000 tons, against 4,605,000 tons in 1893, and 4,200,000 tons in 1892. As this market is practically independent of fluctuations in freights there is always a steady demand for the ore.

Cartagena.—This district has probably been more severely affected than any other by low prices, high freights, and competition with richer ores from other districts. There is, however, no doubt that a large quantity of good manganiferous and dry iron ore can still be extracted from the neighborhood of Cartagena and Portman, and the following analyses show the quality of some of the ores exported during the past year:

	No. 1 Manganiferous.	Cartagena Ore.	Portman Ore.
Carbonic acid, etc.	16.33	15.07	11.46
Lime	.....	1.33	0.31
Silica	5.14	5.35	11.40
Ferric oxide	35.85	74.28	74.35
Manganese oxide	30.89	0.85	0.33
Alum	0.31	3.02	0.50
Magnesia	0.45	0.10	0.12
Oxide of zinc	0.86	.....	0.76
Sulphuric acid	0.31	0.06	0.21
Phosphoric acid	0.04	0.03	0.04
Titanic acid	.....	0.05	.....
Moisture	9.80	.....	.....
Metallic iron	25.09	52.00	52.12
Metallic manganese	22.26	0.64	0.30

The manganiferous ores of the Cartagena district are sold on the following basis: No. 1, 20% manganese, 20% iron, 11% silica; No. 1B, 17% managanese, 25% iron, 11% silica; No. 2, 15% manganese, 30% iron, 11% silica; No. 3, 13% manganese, 35% iron, 11% silica.

The exports from Cartagena and Portman of iron and manganiferous ores during 1894 have been 233,000 tons, which went to the following countries: United Kingdom, 178,800 tons; Holland, 28,600 tons; France, 21,000 tons; United States, 4,600 tons. The exports during the last five years have been: 1890, 824,100 tons; 1891, 421,200 tons; 1892, 518,000 tons; 1893, 214,558 tons. The shipments in 1894 took place chiefly early in the year, and were to a great extent old stocks, the actual quantity of ore mined during the year being small.

The number of iron ore mines officially declared as working were 22, against 28 in 1893. In order to give an idea of the demoralized state of this industry it is sufficient to say that six years since the district gave employment to over 20,000 miners; in 1893 the laborers employed were only 11,000, and to-day there are barely 5000 remaining, and for these it is impossible to find employment.

Besides the mines in the immediate neighborhood of Cartagena, enterprise and capital only are required for the opening of the rich iron ore deposits of the Sierras of Carrascoy and Cehegin; these latter produce a magnetic ore yielding an average of over 60% metallic iron, and the available quantity of ore has been estimated at 4,000,000 tons. Samples taken from the different workings give the following results: No. 1, 66.72% iron, 3.80% silica, 0.02% phosphorus, 2.25% lime; No. 2, 62.90% iron, 4.06% silica, 0.019% phosphorus, 4.50% lime; No. 3, 59.00% iron, 6.50% silica, 0.03% phosphorus.

The iron ore mines at Perin, situated nine miles from Cartagena, yield an ore rich in metal, but as it is a specular micaceous ore it is not much in favor with ironmasters; it is considered as of a refractory nature, too high in sulphur, and owing to its powdery character it is in bad mechanical condition for the furnace. An analysis is as follows: Iron, 63.25%; silica, 2.50%; sulphur, 0.109%; manganese, traces. At one time this ore was shipped largely to the United States.

Seville.—The rich iron ore mines known as the "Pedroso," or "Monte de Hierro" mines, situated 92 kilometers from Seville, form without doubt one of the finest deposits in the south of Spain. Great progress has been made during the past year in the completion of the connection between these mines and the main line of the Merida & Seville Railroad, and preparations are being made to extract and haul a minimum of 1000 tons of ore per day. Unfortunately there is one great difficulty in the way of handling these minerals on a large scale, and that is the defects of Seville as a shipping port. Not only are there no facilities for the prompt loading and despatch of steamers, but there is so little water in the river that a special class of steamers will have to be employed to carry the ore. The river at Seville will admit no boats drawing over 14 ft. of water.

Besides the above mines there is also the Guardacanal group, situated 104 kilometers from Seville, and the Lima mines at Pedroso; but neither of these groups are of an importance, as regards either the quantity or quality of the ore, to be compared with the Monte de Hierro mines.

Garrucha.—The quantity of Garrucha ore shipped during 1894 has been 111,050 tons, which was mostly shipped early in the year. The quantity of iron ore shipped in the month of December was: 1892, 18,800 tons; 1893, 7600 tons; 1894, 950 tons. The quantity of ore in stock on the beach at the end of December, 1894, was 90,000 tons.

LEAD MINING AND SMELTING.

Owing to the low price of lead and silver, and the fall in exchange during the latter part of the year, there has been a considerable falling off in the output of the mines and smelting works. The total production in the Peninsula of pig-lead for the year 1894 was about 169,000 tons, against 189,000 tons in 1893.

Adra.—The exports from this port during the past year have been: Lead ore, 344 tons; pig-lead, 2757 tons.

Cartagena.—During 1894 there have been 15 smelting works in blast, averaging two furnaces to each. The total 30 furnaces produced an average of about 6000 tons of pig-lead per month. The number of mines actually working has been about 80, against 100 in 1893; the deepest workings are at 300 meters.

The amount of pig-lead shipped from the ports of Cartagena and Portman in 1894 was 57,300 tons, against 69,350 tons in 1893. The amount of silver contained in the lead was 2,290,000 ozs. The production of 1893 went to the following countries:

	Silver Lead.	Soft Lead.	Total, Tons.
United Kingdom	35,022	7,131	42,153
France	16,620	3,751	20,371
Belgium	5,150	.....	5,150
Barcelona	.....	1,680	1,680
Total	56,792	12,562	69,354

The only new feature in the lead business has been the shipment of lead ore to Glasgow for the manufacture of the new non-poisonous white lead direct from the ore.

Linares.—The number of lead mines registered in the Linares district is 938, of which, however, only about 200 are actually working. The production of ore from these mines has been about 105,000 tons of galena and carbonates, equivalent to 90,000 tons of metallic lead. The ore smelted in Linares has been about 60,000 tons, equivalent to 46,200 tons of metallic lead, the silver obtained from which was about 385,800 ozs.

The amount of fuel consumed in the Linares lead works was 76,000 tons coal and 4500 tons coke, nearly all of which is supplied from the mines at Belmez at the price of about $8.50 per ton for coal and $9.00 for coke, delivered in Linares.

Mazarron.—There was very little variation in the aspect of trade in this district from 1893, and the mines have put out about the same proportion of ore, with the exception of an increase in the Vista Alegre mine, and a falling off in the output of the Talia; the total output of the mines having been about 90,000 tons of ore, most of which is smelted in the fine lead works of the Compañia Metalurgica de Mazarron, the remainder being shipped to Cartagena and there smelted.

The following table shows the production of lead ore from each mine for the years 1892 and 1893, with the contents of silver per ton of mineral. The workings in all these mines are carried on at a depth of from 200 to 400 meters. The ore-bearing area is not extensive, and all the mineral is raised within a radius of less than three miles.

	1892.			1893.			1894.
	Ore Production, Tons.	Lead, Per Cent.	Silver, Oz. Per Ton	Ore Production, Tons.	Lead, Per Cent.	Silver, Oz. Per Ton	Ore Production, Tons.
Impensada	9,800	60	25.0	7,200	60	25.0	.....
Triunfo	26,400	66	30.0	27,000	66	30.0	.....
Santa Ana	14,400	60	20.0	21,600	60	20.0	.....
San Antonio	3,600	64	30.0	4,800	64	30.0	.....
Fuensanta	2,400	50	20.8	2,200	50	20.8	.....
Urserpada	1,800	60	26.0	2,900	60	26.0	.....
Santa Isabel	4,000	64	30.0	4,800	64	30.0	.....
San Carlos	1,000	70	26.0	800	70	26.0	.....
San José	3,600	64	32.0	1,200	64	32.0	.....
Talia	18,200	70	28.0	16,800	70	28.0	.....
San Vicente	800	56	28.0	50	56	28.0	.....
Vista Alegre	5	40	30.0	30	40	30.0	.....
Total	86,005	.....	.....	89,380	.....	.....	90,000

Other Mines.—Other mining centers of interest in Spain are the Horcajo argentiferous lead mines near Ciudad Real, the Posadar mines near Cordoba, the argentiferous galena mines of Plazanzuela in the Province of Paceres, and the Sierra Almagrera argentiferous mines in the Province of Almeria. Many of these latter have been unable to extract the rich silver ore they contain owing to the quantity of water in the mines. This difficulty will soon be overcome, as a Hamburg firm has undertaken to drain the entire zone, which covers an area of some 20 miles, and an enormous pumping plant has already been installed.

SWEDEN.

THE mineral industry of Sweden is comparatively an ancient one and still continues to increase in some directions. Of recent years it has shown more changes of importance than for a long time previously. Perhaps the most important of these to the country is the decline in the price of and demand for Swedish iron, which for so many years had a market peculiarly its own, from which it could not be displaced owing to its special qualities and the care taken in its manufacture. The chief cause for this change has been the increasing production and use of steel both in England and America. In many directions steel is now employed where Swedish iron was formerly thought necessary, and the manufacture has suffered accordingly.

To some extent the Swedish iron-masters have met this change of affairs by giving attention to the manufacture of steel. Both Bessemer and Siemens-Martin metal are made in Sweden of admirable quality owing to the purity of the ores. The Siemens-Martin process has met with especial favor, and the quantity of open-hearth steel reported is almost equal to that of Bessemer.

The coal production of Sweden is limited and has apparently reached its maximum. The coal-beds now worked have been thoroughly explored and it is not expected that this production will be extended. The production of copper ore remains nearly stationary; most of this ore is exported either as ore or matte, a comparatively small amount of metallic copper being reported among the products of the country. The following tables show the production of Sweden for the years from 1890 to 1893 inclusive, with such figures as could be obtained for 1894. The statements for the years prior to 1890 will be found in THE MINERAL INDUSTRY, Vols. I. and II.

MINERAL PRODUCTION OF SWEDEN. (*a*) (IN METRIC TONS.)

Year.	Alum.	Cement		Coal.	Cobalt Ore.	Copper Ore.	Fire Clay.	Gold Ore.	Iron Ore	Iron Bog Ore.	Iron Pyrites	Mang. Ore.	Nickel Ore	Plumbago.	Pyrolusite (Powder'd)	Red Ocher.	Silv'r and Lead Ore.	Zinc Ore.
		Value.																
1890	.981	$477,729		187,512	145	20,670	126,003	1,457	940,429	812	1,134	10,698	616	14	45	1,534	14,986	61,843
1891	.542	487,858		198,033	244	21,823	134,909	2,680	985,255	2,150	1,659	9,079	483	17	192	1,468	15,044	61,591
1892	.346	581,188		199,380	53	24,069	123,096	3,463	1,291,933	1,650	1,249	7,832	.....	15	172	1,090	19,803	54,981
1893	.357	507,668		199,933	101	22,033	138,469	2,441	1,481,487	2,275	480	7,061	.....	49	.....	1,370	21,043	46,623
1894	....	.....		.....	....	.....	.....	.....	.....	.....	.....	.....	.....	....	.....	.....	.....	.....

Year.	Brass.	Cobalt Oxi. Kilos	Copper.	Copperas.	Copper, Hammer'd	Copper, Sulph'te	Gold, Kilos.	Iron. Pig.	Iron. Bloom.	Iron. Bar.	Steel. Bessemer.	Steel. Siemens Martin.	Steel. Other.	Mf'rs of Iron and Steel.	Lead.	Silver, Kilos.	Sulphur.	Sulphuric Acid.
1890..	275	7,020	.617	500	363	636	87,664	456,103	225,632	281,833	94,247	72,985	2,055	78,998	310	4,555	42	16,714
1891..	293	6,260	.543	419	308	612	109.580	490,913	224,651	280,430	92,985	78,197	1,592	72,438	299	3,658	23	18,172
1892..	302	7,138	.745	476	314	580	87.626	485,664	235,426	273,510	82,422	76,556	1,494	.....	799	5,211	46	28,147
1893..	497	3,298	.543	454	389	659	93.376	453,421	225,533	266,727	84,389	81,889	1,222	.....	461	4,464	75	27,324
1894..	....	.....	.....	.....	.....	.....	.....,	.....	.....	.....	.....	.....	.....	.....	...	.....	...	.....

(*a*) From *Bidrog till Sveriges Officiela Statistik, Bergshandteringen,* and *Tullkomitens Betänkande.* II., Bilaga 1, Stockholm, 1891. There were also produced of allanite 20 and 14 tons in 1890 and 1891; of litharge, 66 tons in 1890–92; of nickel matte, etc., 586 tons in 1889–91. In 1892 there was also an output of 16 tons of cement copper.

While the exports of iron have shown some decline those of iron ore have increased rapidly. The Gellivara ore deposits in Swedish Lapland furnish a large proportion of the exports.

The exports for five years will be found in the table below:

MINERAL EXPORTS OF SWEDEN. (*a*) (IN METRIC TONS; 1 krone=27c.)

Year.	Glass.		Iron Manufactures.		Iron, Pig.		Machinery.	Zincblende.	
1890....	5,287	$447,660	227,422	$9,752,940	60,125	$1,107,270	$825,930	31,903	$430,650
1891....	6,084	554,850	208,037	8,760,960	63,096	1,022,220	873,990	31,168	420,660
1892....	5,949	697,865	209,073	8,425,095	57,502	923,583	866,321	29,482	398,011
1893....	6,995	1,005,343	190,028	7,327,365	59,836	940,271	972,805	26,772	361,425
1894....	.....	.....	.....	.....	67,172	.....	.....	24,822	.....

Year.	Cement.		Cobalt, Kilos.		Copper Ore.		Iron Ore.		Silver, Kilos.		Soda.	
1891....	14,322	$154,671	7,306	$13,808	181	$3,423	174,148	$470,200	2,058	$87,794	1,610	$43,476
1892....	25,128	271,382	.....	.....	162	3,066	320,071	864,193	4,878	197 559	1,491	28,186
1893....	41,399	391,225	.....	.....	204	3,848	484,055	1,306,948	3,981	161,230	823	15,546
1894....	.....	.....	.....	.....	.....	.....	834,295	....	.....	.....	.....	.....

(*a*) Other exports: Coal tar, 1891, 1338 tons, $14,446; 1892, 1798 tons, $24,268; 1893, 2310 tons, $18,712; alum, 1891, 56 tons, $1624; 1892, 64 tons, $2079; 1893, 82 tons, $2430; chalk, 1891, 6639 tons, $54,000; 1892, 4666 tons, $46,980; 1893, 4254 tons, $34,560; copper, 1891, 145 tons, $37,520; 1892, 695 tons, $169,830; 1893, 390 tons, $81,810.

The imports of Sweden are given in the table below. It will be seen that coal and coke form the largest single item in the list.

MINERAL IMPORTS OF SWEDEN. (*b*) (IN METRIC TONS.)

Year.	Coal and Coke.		Iron and Steel.		Iron Manufactures.	Machinery.	Mineral Oil.
1890.....	1.972,411	$8,774,830	38,353	$1,112,940	[$2,325,780	$3,995,190	$1,854,090
1891.....	2,092,062	8,358,660	36,037	1,131,300	2,645,170	3,831,300	1,667,790
1892.....	2.078,711	6,970,216	40,167	1,085,163	3,166,971	3,082,450	1,572,631
1893.....	2,079,579	6,924,148	27,005	900,920	3,252,817	1,926,210	1,831,279
1894.....	2,548,200	.....	.....	.....	.....	.....	.....

Years.	Antimony, Crude.		Asphaltum.		Calcium Chloride.		Cement.		Gypsum.		Saltpeter.		Salt.		Sulphur.	
1891....	83.78	$2,432	2,382	$35,583	1,128	$48,709	896	$11,123	1,331	$17,972	4,491	$363,809	.....	$492,482	4,402	$154,523
1892....	58.10	10.981	1,981	21,400	1.083	43,884	719	8,940	1,207	16.295	5,301	572,520	95,505	478,509	7.416	240,283
1893....	41.00	7,749	1,967	21,241	1,072	49,212	852	9,434	1,221	16,484	.....	.....	93,143	466,256	8,876	215,690

(*b*) From *Bidrog till Sveriges Officiela Statistik; Utrikes Handeln.* Other imports: Coal tar, 1891, 1652 tons $22,309; 1892, 1832 tons, $24,730; 1893, 1545 tons, $12,514; white lead and zinc oxide (together), 1891. 1191 tons, $125,497; 1892, 562 tons, $56,160; white lead, 1893, 282 tons, $26,730; zinc oxide, 1893, 1170 tons, $157,950; alum, 1891, 84 tons, $2430; 1892, 112 tons, $2970; 1893, 87 tons, $2160; glass. all kinds, 1891, 2663 tons, $774,200; 1892, 1614 tons, $411,480; 1893, 1451 tons, $376,650; copper ingots, 1891, 1749 tons, $460,350; 1892, 1415 tons, 405,810; 1893, 2156 tons, $520,560.

UNITED KINGDOM.

During 1894 the mineral industry of the United Kingdom suffered much less from strikes and other industrial disturbances than in 1892 and 1893, and the result appears very clearly in the tables below, in which the production for the five years from 1890 to 1894 inclusive is given; the statistics for the years previous to 1890 will be found in The Mineral Industry, Vols. I. and II.

The coal production, which suffered so heavy a loss in 1893 in comparison with previous years, rose in 1894 to a point nearly 3,000,000 tons in excess of the prosperous year of 1891. Part of this increase was absorbed by the greater exports of the year, but part also was required to meet an increased demand for the iron trade. The latter showed for the year a gain in activity notwithstanding a certain amount of depression and a marked decline in price obtained for the output. Iron ore continued to show a decreased production; this is due to the partial exhaustion of some of the British mines and to the fact that in many others the increase in production costs prevents them from competing effectively with the imported ores. In many districts Swedish and Spanish ores of excellent quality can be laid down at the furnaces at a lower price than they can be supplied from the native mines. During the past two or three years special attention has been drawn to the Swedish mines as a source of supply, with the result of largely increasing the imports from that country.

In other respects there is but little to be said of special importance with regard to the production of the past years. References will be found to the coal, iron, tin and other important items of the production under the respective heads.

MINERAL PRODUCTION OF THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND. (*a*)
(IN METRIC TONS.)

Year.	Alum Shale.		Arsenic. (*b*)		Arsenical Pyrites.		Barytes.		Bauxite.		Clays. (*c*)	
1890..	6,525	$4,010	7,395	$303,635	5,198	$22,070	25,769	$148,420	11,716	$28,815	3,362,447	$4,495,830
1891..	5,564	3,410	6,147	292,965	5,179	21,850	27,317	160,600	10,939	16,140	3,274,855	4,719,480
1892..	2,969	1,825	5,196	218,430	4,569	24,940	24,637	146,415	7,440	9,300	3,153,824	4,446,875
1893..	2,184	1,320	6,170	288,470	3,134	14,740	2,306	126,815	9,022	20,750	3,164,702	4,087,095
1894..	4,035	.....	4,830	.....	3,337	.....	20,985	.....	8,097	.....	2,330,194	.....

Year.	Coal.		Cobalt and Nickel Ore.		Copper Ore.		Copper Precipitate.		Fluorspar.		Gold Ore. (c)		Gypsum.	
1890	184,594,850	$374,769,985	85.37	$1,300	12,333	$139,005	351	$23,350	272	$1,260	584	$2,070	142,592	$289,955
1891	188,519,767	370,499,080	Nil.	.....	8,981	101,070	327	21,775	143	935	14,348	62,000	154,195	300,190
1892	184,713,640	330,252,255	.....	.....	6,092	57,965	274	15,560	174	940	10,151	45,840	149,915	291,135
1893	169,659,680	279,049,040	.....	.....	5,535	64,805	.....	12,050	238	805	4,634	38,285	148,143	296,845
1894	191,289,965	.....	.....	.....	5,844	.....	445	.....	31	.....	6,708	.....	115,032	.....

Year.	Iron Ore.		Iron Pyrites.		Lead Ore.		Manganese Ore.		Ocher and Umber.		Oil Shale.	
1890	14,066,681	$19,632,225	16,281	$35,330	46,399	$2,030,820	12,646	$33,665	19,381	$87,375	2,248,516	$3,041,845
1891	12,987,159	16,779,300	15,716	40,010	44,578	1,783,915	9,632	31,065	13,825	100,515	2,399,826	3,535,885
1892	11,494.809	14,853,160	14,142	34,785	40,668	1,482,420	6,176	22,170	12,326	83,910	2,123,585	2,612,420
1893	11,567,132	141,897,735	16,351	36,460	40,664	1,402,695	1,380	3,810	10,876	69,400	2,020,027	2,445,650
1894	.....	.....	15,169	.....	41,463	.....	1,806	.....	2,497	.....	2,018,167	.....

Year.	Phosphate of Lime.		Salt. (e)		Slates and Slabs.		Sulphate of Strontia.		Tin Ore. ("Black Tin.")		Wolfram.		Zinc Ore.	
1890	18,295	$147,500	2,182,045	$5,500,070	441,473	$5,136,175	10,444	$25,690	15,155	$3,912,460	106	$8,340	22,402	$549,450
1891	10,164	100,000	2,077.072	4,884,120	421,829	4,835,000	8,193	20,150	14,726	3,676,200	140	16,705	22,580	567,225
1892	12,396	111.250	1,988,024	4,307,005	424,975	5.129,610	5,147	6,330	14,588	3,672,825	127	15,000	24.264	520,080
1893	3,386	28,853	2,015,027	3,676,110	453,242	5,538,138	6,000	11,625	14,132	3,185,265	22	2,100	24,524	406,350
1894	.....	.....	20,062	.....	173,883	.....	.....	.....	13,336	.....	.....	.....	22,023	.....

(a) Production figures for 1894 are from mines under the jurisdiction of the Mine Inspectors, whose reports are published in the "Summaries of Statistics" report. Other minerals reported for 1894 were: Ganister, 96,523 tons; limestone, 32,963 tons; shale, 6727 tons; mineral oil, 50 tons; honestone, 350 tons; soapstone, 10 tons; uranium ore, 13 tons; red oxide of iron, 878 tons; "shining ore," 234 tons; iron ore and ironstone, 9,223,788 tons.
(b) White arsenic, crude and refined, produced from arsenical pyrites not included in the next column.
(c) China clay, potter's clay, fuller's earth, etc., but exclusive of ordinary clays.
(d) Auriferous quartz.
(e) Rock salt and salt obtained from brine.

PRODUCTION OF CERTAIN METALS IN THE UNITED KINGDOM. (IN METRIC TONS.)

Year.	Fine Copper.	Metallic Lead.	White Tin.	Zinc.	Silver from Lead. Kilos.
1890	941	34,140	9,752	8,692	9,043
1891	731	32,733	9,503	9,037	8,673
1892	503	30,014	9,419	9,500	8,436
1893	439	30,173	9,124	9,585	8,663

The imports are given in the following tables and show for 1894 comparatively light changes. Perhaps the most important is the growth in the imports of iron ore, which is referred to above. Another feature to be noticed is the large increase in imports of metallic copper with a corresponding decrease in those of precipitate and matte. This change is largely due to the fact that shipments of matte from this country have almost ceased, all of our companies now refining their copper at home instead of sending any portion of it abroad in the crude state. In fact for the last year or two the copper works of Swansea have had some difficulty in securing supplies of raw material.

MINERAL IMPORTS OF THE UNITED KINGDOM. (IN METRIC TONS; £1=$5.)

Year.	Alkali.		Brimstone.		Copper Ore.		Copper Regulus and Precipitate.		Copper, Unwrought and Part Wrought.		Chemical Products.
1891	4,428	$252,020	21,769	$647,485	90,423	$3,664,550	125,323	$16,507,525	44,958	$11,819,550	$6,845,365
1892	2,857	207,580	26,499	738,905	93,399	2,926,865	136,328	16,450,530	35,626	8,279,710	7,511,470
1893	4,456	395,520	26,171	624,985	82,099	2,430,110	120,621	14,164,700	42,694	9,571,585	6,778,230
1894	7,908	519,120	24,281	513,140	84,138	2,468,125	80,114	8,844,835	57,970	11,821,590	6,876,435

Year.	Glass of All Sorts.		Guano.		Iron Ore.		Iron, Bar, Angle, Bolt, and Rod.		Iron, Girders, Beams & Pillars		Iron Manufactures.	
1891	76,659	$9,045,205	24,003	$693,210	3,231,750	$12,267,035	78,674	$3,757,935	75,227	$2,549,400	157,540	$13,823,605
1892	81,111	9,351,095	28,323	947,165	3,841,369	13,584,100	77,137	3,461,295	75,781	2,512,870	146,093	12,660,590
1893	134,665	12,216,295	18,600	473,605	4,131,323	13,960,140	66,810	2,965,165	73,480	2,096,915	153,130	12,728,195
1894	106,478	11,346,775	28,661	720,555	4,485,880	14,917,985	64,265	2,777,790	70,537	2,141,150	157,387	13,164,025

Year.	Steel, Unwrought.		Lead, Pig and Sheet.		Nitrate of Soda.		Paraffine.		Petroleum, Liters.		Phosphate of Lime and Rock.	
1891....	8,572	$437,840	172,456	$10,688,370	123,998	$5,249,090	28,418	$4,025,170	494,378,537	$13,426,840	260,906	$3,141,975
1892....	6,587	312,430	185,725	9,882,180	121,486	5,100,960	28,074	3,748,520	492,754,491	12,234,530	319,187	3,328,445
1893....	9,079	452,530	194,252	9,276,075	88,169	4,030,985	39,025	4,069,685	577,151,861	12,733,800	328,461	2,972,335
1894....	8,726	384,295	163,970	5,259,275	127,697	5,845,765	31,835	3,165,295	728,980,574	12,424,380	386,102	3,614,675

Year.	Pyrites, Iron, Copper, or Sulphur.		Quicksilver.		Saltpeter.		Silver Ore.	Tin, in Blocks, Ingots, Bars, or Slabs.		Zinc, Crude, in Cakes.		Zinc Manufactures.	
1891	626,148	$5,631,235	2,135	$2,537,515	14,163	$1,255,105	$18,831,695	28,661	$12,825,370	59,455	$6,647,525	20,483	$2,571,980
1892	614,142	5,317,530	1,939	1,980,920	15,666	1,339,655	15,160,845	29,942	13,719,070	53,643	5,512,955	19,263	2,315,400
1893	622,634	5,327,035	1,767	1,705,930	12,323	1,069,370	15,354,655	34,093	14,460,535	57,842	5,036,985	18,739	1,991,765
1894	625,968	5,258,510	1,952	1,516,810	14,694	1,327,795	12,199,775	39,777	13,592,495	54,768	4,098,745	18,844	1,775,110
(*c*)													

(*a*) From *Mineral Statistics of the United Kingdom.*
(*b*) 1894 does not include bottles, of which were imported 821,728 gross, valued at $2,129,260.
(*c*) From the Board of Trade returns.

The export tables show some changes, but none of marked importance. Perhaps the most notable one is the diminution in exports of railroad material, which show how the business depression of the past two years has stopped railroad construction to a great extent almost all over the world. While the English rail mills have not, perhaps, felt the effects of the depression quite as severely as our own did for a time, it has nevertheless affected them very seriously. The exports of alkali and similar products show that the chemical industry, which holds such an important place among British manufactures, is not diminishing.

MINERAL EXPORTS OF THE UNITED KINGDOM. (*a*) (IN METRIC TONS.)

EXPORTS OF DOMESTIC PRODUCE.

Year.	Alkali.		Brass and Manufactures.		Cement.		Coal, Coke, Cinders, and Fuel.		(*b*) Coal, etc., for Steamers	Coal Products. (*c*)	Copper, Unwrought, in Ingots.	
1891	316,383	$11,676,405	5,793	$2,583,030	585,242	$5,703,485	31,584,570	$94,475,390	8,673,933	$7,849,570	35,928	$9,823,740
1892	299,018	10,597,200	5,498	2,272,685	500,546	4,514,550	30,944,282	84,053,790	8,738,591	6,661,365	42,972	10,307,220
1893	296,481	9,289,640	5,877	2,291,165	444,898	3,722,120	29,512,740	71,877,380	8,257,207	6,375,310	28,802	6,836,460
1894	303,786	8,148,895	6,527	2,023,575	432,782	3,519,755	33,600,000	86,879,035	9,444,000	6,319,215	19,770	4,255,585

Year.	Copper, Wrought or Manufactured.		Mixed or Yellow Metal.		Earthenware.	Glass of All Sorts	Hardware and Cutlery.	Implements, Tools and Parts.	Iron, Pig.		Iron, Bar, Angle, Bolt, and Rod.	
1891	16,425	$5,384,245	66,650	$19,140,560	$9,791,720	$5,067,085	$12,637,875	$6,557,865	853,580	$11,027,835	220,617	$7,314,500
1892	16,478	4,864,985	74,619	18,817,645	9,523,560	4,426,525	10,973,630	6,310,245	779,402	9,873,725	176,206	5,738,410
1893	17,277	4,861,505	66,889	3,410,870	9,117,405	3,829,700	10,233,030	6,130,725	853,391	9,857,590	151,329	4,647,760
1894	15,664	4,146,425	16,213	3,435,155	8,038,700	3,582,385	9,190,630	5,922,985	843,815	9,561,750	121,269	4,112,785

Year.	Iron, Railroad of All Sorts.		Iron and Steel Wire and M'f's Excpt Tel. Wire		Iron Hoops, Sheet, Boiler, Armor.		Iron, Galvanized Sheets.		Tin, Plates and Sheets.		Iron, Cast and Unwrought, and Manufactures.	
1891..	713,553	$19,263,820	68,603	$5,715,635	160,000	$6,252,705	166,541	$11,550,540	455,598	$35,833,275	370,778	$24,032,005
1892..	475,538	11,236,110	48,112	3,969,575	142,373	6,318,035	159,649	10,385,340	401,866	26,651,080	325,059	21,811,445
1893..	567,823	12,555,070	37,735	3,237,305	141,845	6,096,035	169,407	10,228,750	385,480	24,956,500	285,095	18,825,125
1894..	430,416	9,427,840	35,380	3,107,110	131,803	5,237,555	172,536	9,760,330	359,782	21,751,085	270,589	17,190,325

Year.	Old Iron for Remanufacture.		Steel, Unwrought.		M'f's of Steel or Steel and Iron Combined.		Total of Iron and Steel.		Lead, Pig, Sheet, Piping, and Manuf'res.		Locomotives.	Mining Machinery.
1891	112,856	$1,771,845	152,874	$8,660,365	17,311	$2,962,475	3,292,312	$134,385,000	49,010	$3,412,395	$8,086,270	.....
1892	108,202	1,638,080	151,532	8,703,270	15,491	2,503,770	2,783,381	108,828,840	59,098	3,542,550	4,918,760	.....
1893	120,461	1,671,370	170,407	8,509,170	18,826	2,378,110	2,903,753	102,962,885	49,723	2,763,005	4,213,300	$2,047,525
1894	87,387	1,134,365	215,428	9,881,090	19,158	2,490,465	2,699,345	93,655,700	47,905	2,594,340	3,750,195	1,933,555

Year.	Salt, Rock, White.		Telegraph Wire and Apparatus.	Tin, Unwrought.		Zinc or Spelter, Unwrought & Wrought	
1891.....	682,078	$2,982,040	$7,170,100	5,249	$2,457,460	7,798	$808,665
1892.....	664,668	2,696,310	4,549,585	5,738	2,720,335	9,974	894,880
1893.....	646,389	2,522,500	5,314,435	6,848	3,031,995	9,895	793,155
1894.....	771,398	3,020,675	7,087,230	2,898	2,160,950	9,372	635,645

EXPORTS OF FOREIGN PRODUCE.

Year.	Chemical M'f's and Products.	Copper, Unwrought and Part Wrought.		Glass of All Sorts.		Guano.		Iron, Bar, Angle, Bolt, and Rod.	
1891.....	$808,890	11,874	$3,290,605	5,229	$504,765	1,073	$52,290	57,034	$2,282,105
1892.....	1,083,545	11,261	2,797,665	4,516	460,360	1,961	60,000	47,225	1,914,320
1893.....	984,285	13,050	3,066,395	4,702	431,860	1,472	63,670	28,533	1,199,960
1894.....	1,081,660	6,597	1,394,975	4,735	372,505	1,549	53,785	18,963	700,685

Year.	Steel, Unwrought.		Iron and Steel Manufactures.		Petroleum, Liters.		Quicksilver.		Saltpeter.		Tin, in Blocks, Ingots, Slabs, or Bars.	
1891.....	4,291	$230,795	29,750	$2,367,790	4,370,092	$267,855	1,928	$2,222,845	1,219	$111,715	14,856	$6,694,470
1892.....	3,004	147,390	38,761	2,638,255	9,010,298	527,005	1,713	1,662,885	1,574	131,335	16,627	7,665,500
1893 *k*.....	4,983	246,440	47,860	2,925,770	5,988,157	339,155	1,298	1,200,240	1,396	110,255	19,377	8,441,810
1894 *k*.....	3,789	146,520	35,521	2,117,910	7,497,161	288,525	1,482	1,296,890	2,716	237,195	21,887	7,615,235

(*a*) From *Accounts Relating to Trade and Navigation of the United Kingdom.*
(*b*) Coal, etc., shipped for the use of steamers engaged in the foreign trade. This not being an export in the ordinary acceptation of the term, the value thereof is not given in the returns.
(*c*) Including naphtha, paraffine, paraffine oil, and petroleum.

The tables above show to how great an extent the imports of Great Britain consist of raw materials and the exports of finished products, again illustrating what has always been the chief reason for the great wealth of the country.

OTHER COUNTRIES.

WE GIVE below such statistics of other countries as can be obtained; in all cases the mineral industry of the States named is not important.

Denmark.—Denmark produces only clay products, stone and some peat for fuel. Its imports and exports are given in the following tables:

MINERAL IMPORTS OF DENMARK. (*a*) (IN METRIC TONS; 1 krone=27 cents.)

Year.	Coal.		Glasswares.		Iron and Steel Wares.		Petroleum and Other Oils.		Stone, Rough and Hewn.	
1890....	1,500,715	$6,077,970	2,836	$731,970	69,472	$5,624,100	28,784	$1,492,020	113,842	$1,724,760
1891....	1,614,943	6,278,850	3,016	693,630	78,987	5,827,950	38,738	1,793,340	121,427	1,863,000
1892....	1,640,850	5,859,000	3,367	290,790	71,110	4,881,870	38,379	1,588,140	145,119	2,329,290
1893....	1,598,960	5,848,520	3,261	272,334	69,452	5,969,855	47,774	1,543,701	.....	.....

MINERAL EXPORTS OF DENMARK. (IN METRIC TONS.)

Year.	Coal.		Iron and Steel Manufactures.		Petroleum and Other Oils.		Stone and Manufactures Thereof.		Metal Wares, except Iron & Steel	
1890....	143,284	$603,450	9,343	$983,610	3,862	$243,270	66,622	$385,560	2,674	$1,608,660
1891....	167,964	609,130	14,302	1,091,880	7,930	492,480	68,825	363,420	2,728	1,767,420
1892....	144,771	541,032	9,629	833,760	8,650	384,160	98,825	737,370	3,107	1,901,610
1893....	141,490	540,017	7,462	791,377	11,303	416,901	104,642	954,952	.....	.....

(*a*) Statistics of Denmark for 1893 were kindly furnished by the Statistische Bureau, Copenhagen.

Egypt.—This ancient country has always depended upon agriculture alone, and has no mineral industry of its own. The following table shows its mineral imports:

MINERAL IMPORTS OF EGYPT. (*a*) (£1 Egypt=$5.)

Year.	Coal.	Copper, Bronze and Zinc, Wrought and Unwrought.	Iron and Manufactures of.	Machinery.	Petroleum.
1890.....	$2,457,475	$302,520	$1,323,730	$937,660	$655,055
1891.....	2,369,225	524,215	2,344,410	837,455	721,190
1892.....	3,087,000	543,710	2,202,215	1,087,835	801,260
1893.....	.....	.....	.....	.....	.....

(*a*) From British Statistical Abstracts.

Holland.—Holland produces only a little coal. The country holds an important position in the metal markets of the world, owing to its extensive commerce and its ownership of colonies; but its own mineral output has always been very small. The following tables show the imports and exports:

MINERAL IMPORTS AND EXPORTS OF HOLLAND. (*a*) (IN METRIC TONS; 1 gulden=40 cents.)

IMPORTS.

Years.	Coal.		Copper Ore.		Copper, Raw.		Guano.		Iron, Pig.	Iron Manuf'res.
1890.....	3,883,000	$15,533,200	91,700	$5,868,800	21,961	$8,784,400	14,482	$926,800	8,867,600	$21,492,400
1891.....	4,511,000	18,044,000	91,343	5,846,000	22,827	9,130,800	16,511	1,585,200	7,544,800	25,598,800
1892.....	4,272,000	17,088,000	91,773	5,873,600	21,851	8,726,000	21,961	1,405,600	6,002,840	28,723,200

	IMPORTS.										EXPORTS.	
Year.	Petroleum.		Potash, Pearlash, Soda, etc.		Saltpeter, Unrefined.		Spelter, or Zinc.	Steel and Manuf'es.	Tin, Unwrought		Copper, Unwrought.	
1890	103,817	$10,381,600	38,830	$4,038,400	46,528	$5,583,200	$4,684,000	$17,257,600	9,276	$3,710,400	16,223	$6,489,200
1891	114,008	3,234,400	39,051	4,061,200	53,370	6,404,400	4,164,800	13,756,400	11,944	4,777,600	18,768	7,507,200
1892	123,238	49,295,000	33,767	3,511,600	48,193	5,783,000	4,033,000	14,947,600	12,692	5,007,680	17,096	6,838,400

Year.	Guano.		Iron, Pig.	Iron Manufactures.	Saltpeter, Unrefined.		Spelter or Zinc, Unwrought.		Steel and Manufactures.		Tin, Unwrought.	
1890....	14,215	$909,600	7,547,600	$15,928,800	44,609	$5,353,200	27,437	$2,743,600	50,807	$8,447,600	10,498	$4,199,200
1891....	.....	.....	6,097,200	17,001,600	46,223	5,546,800	.....	.....	41,041	7,140,800	10,671	4,268,400
1892....	.....	.....	4,957,000	14,571,600	40,977	4,883,600	.....	.....	38,320	6,896,400	10,976	4,390,400

(*a*) From British Statistical Abstracts.

Norway.—The mineral production of Norway, with its imports and exports, are shown in the following tables. Copper ore—chiefly from the Vigsnaes mines is the most important item. The production of phosphates (apatite) is not increasing. Nickel ore and iron pyrites are products of some importance.

MINERAL PRODUCTION OF NORWAY. (*a*) (IN METRIC TONS; 1 krone=27 cents.)

Year.	Apatite.		Cobalt Ore.		Copper Ore.		Feldspar.		Iron Ore.		Nickel Ore.	
1890.....	11,119	$260,182	213	$19,500	18,769	$186,680	11,850	$55,458	1,300	$2,340	8,181	$48,360
1891.....	4,258	54,120	187	13,000	20,939	185,120	12,257	55,900	1,464	2,600	12,839	32,630
1892.....	2,427	44,200	123	8,580	18,888	134,940	5,936	27,820	860	1,430	6,959	18,850

Year.	Pyrites, Iron and Copper.		Silver Ore.		Zinc and Lead Ore.		Cobalt.		Copper.	
1890....	58,669	$262,600	1,311	$161,460	3,941	$35,620	2.60	$7,020	466	$120,900
1891....	49,048	209,560	1,277	149,890	498	4,550	7.00	18,200	677	174,980
1892....	52,570	200,720	1,121	127,400	576	5,200	4.50	13,000	631	138,060

Year.	Iron, Pig and Castings.		Iron, Bar and Steel.		Nickel.		Silver (Fine). (*b*)	
1890.....	517	$6,708	691	$38,480	71	$45,500	5.08	$161,876
1891.....	421	5,252	593	35,776	135	96,980	4.68	145,600
1892.....	610	6,760	488	24,258	97	52,780	4.81	125,840

MINERAL IMPORTS OF NORWAY. (*a*) (IN METRIC TONS.)

Year.	Cement	Coal.	Copper, Sheet.	Iron.						Potassium, Nitrate.	Salt.	Zinc, Sheet.
				Bar.	M'n'f's.	Pig.	Plates.	Rails.	Steel.			
1890.....	14,184	766,995	1,477	17,531	11,924	18,227	9,034	4,330	2,184	320	122,280	702
1891.....	14,372	891,453	1,652	27,271	14,514	22,255	10,590	3,673	1,738	320	126,302	921
1892.....	16,381	903,319	1,478	24,936	15,674	15,206	7,658	8,364	1,383	197	140,401	901
1893.....	14,694	900,154	1,331	22,974	17,722	17,070	10,121	8,482	1,897	290	162,978	1,027

MINERAL EXPORTS OF NORWAY. (*a*) (IN METRIC TONS.)

Year.	Apatite	Building Stone.	Chrome Ore.	Copper Ore.	Crude Barytes.	Feldspar.	Iron Ore.	Limestone.	Nickel Ore.	Silver Ore.	Whetstones.	Zinc Ore.
1890....	11,119	54,623	100	1,233	54,851	11,850	370	555	.....	368	149	3,444
1891....	4,258	41,345	90	1,649	45,689	12,257	752	388	40	304	146	1,102
1892....	2,427	45,598	21	1,845	47,748	5,936	69	769	.....	474	129	629
1893....	1,513	48,691	30	11,874	52,757	3,506	510	857	340	154	109	.....

EXPORTS OF METALS FROM NORWAY. (*a*) (IN METRIC TONS.)

Year.	Cobalt.	Copper.	Nickel.	Iron.					
				Bar Iron.	Castings.	Plates.	Nails.	Pig and Scrap.	Steel.
1890.....	96	557	171	23	224	1	9,788	3,610	178
1891.....	44	597	151	118	173	4	10,019	2,091	154
1892.....	.....	350	56	155	185	17	8,916	2,980	119
1893.....	35	378	177	62	93	2	8,559	4,767	104

(*a*) From *Tabeller vedkommende Norges Bergverksdrift*, Christiania, and from *Meddelser fra det statistiske Centralbureau.* (*b*) Contained 22.549 kilos of gold in 1890, 11.000 kilos in 1891, and 16.177 kilos in 1892.

Portugal.—The following tables show the mineral imports and exports of this country:

MINERAL IMPORTS AND EXPORTS OF PORTUGAL. (*a*) (IN METRIC TONS; 1 milreis=$1.)

IMPORTS.

Year.	Antimony.		Bullion and Specie.		Cement.		Coal.		Coke.		Copper.	
			Gold.	Silver.								
1892..	58	$5,100	.....	.....	9,411	$120,425	603,696	$2,042,790	13,060	$34,715	16	$5,180
1893..	11	1,385	.....	.....	11,124	143,360	525,527	1,835,150	10,628	41,090	21	8,340

Year.	Copper, Drawn and Rolled.		Gold, Bars—Kilos		Gold, Leaf.		Gypsum.		Glass, Broken.		Iron and Rails.	
1892..	581	$189,110	2,589	$1,604,165	17	$1,385	261	$3,610	172	$1,990	44,363	$1,013,720
1893..	560	138,150	1,326	1,000,735	21	1,545	33	580	330	4,050	27,643	1,150,195

Year.	Iron, Rolled.		Iron, Cast.		Iron, Pig.		Iron, Wire.		Iron, Machinery.		Lime, Hydraulic.	
1892..	6,207	$424,975	.....	.....	14	$345	4,937	$216,500	.....	.....	1,169	$8,195
1893..	7,197	450,990	14,299	$142,595	1,363	19,140	5,874	272,105	.....	.....	1,427	12,300

Year.	Lead, Ingots.		Lead, Drawn and Rolled.		Lead, Alloys.		Mercury.		Marble and Alabaster.		Mineral Oils.	
1892..	2,243	$135,180	225	$14,625	30	$1,550	15	$13,075	430	$11,370	15,563	$642,925
1893..	1,789	99,325	426	45,505	.....	50	16	15,185	592	9,040	15,254	653,795

Year.	Other Mineral Substances.		Ores.		Platinum.	Steel, Rails.		Steel, Wire.		Steel, Ingots.		Sulphur.	
1892..	8,841	$45,510	4	$360	$15	1,157	$59,635	5	$1,450	15	$1,845	13,451	$383,340
1893..	9,473	66,040	29	365	105	1,765	88,725	7	2,415	1	60	10,457	220,380

Year.	Silver, Kilos.		Tin, Ingots.		Tin, Rolled.		Tin, Solder.		Zinc.		EXPORTS. Mineral Substances	EXPORTS. Metallic Substances
1892..	85,859	$2,306,180	380	$157,280	6	$3,310	7	$2,910	438	$47,080	$27,220	$10,486,720
1893..	21,981	558,720	377	123,820	5	3,200	.....	320	454	38,635	51,365	6,783,195

(*a*) From British Statistical Abstracts.

SALT PRODUCTION OF ROUMANIA.

Year.	Metric Tons	Year.	Metric Tons	Year.	Metric Tons	Year.	Metric Tons	Year.	Metric Tons
1885.....	70,408	1887.....	86,076	1889.....	87,742	1891....	107,971	1893.....	97,473
1886.....	83,400	1888.....	84,177	1890.....	91,395	1892....	96,098	1894.....	117,161

The production of petroleum in 1893 was 79,052,490 liters, which equals, assuming the specific gravity of the oil at .878, about 69,408 metric tons.

The imports and exports are shown in the following table:

MINERAL IMPORTS AND EXPORTS OF ROUMANIA. (*a*) (IN METRIC TONS; 5 lei=$1.)

Year.	IMPORTS. Coal.		IMPORTS. Iron, Unwrought.		IMPORTS. Iron and Steel Rails.		IMPORTS. Iron, Tin Plates		EXPORTS. Petroleum.		EXPORTS. Salt.	
1890..	243,813	$1,216,400	8,465	$338,600	12,806	$896,400	4,000	$480,000	11,774	$235,400	.....	.....
1891..	336,383	2,160,400	9,706	338,342	21,242	1,487,000	4,627	555,200	18,087	362,400	.....	.....
1892..	300,833	2,204,600	7,951	318,000	13,608	952,600	5,095	611,400	19,773	611,400	.....	.....
1893..	341,061	2,728,486	10,365	414,611	12,514	875,996	c21,104	2,027,320	d17,125	344,176	31,195	$249,563

(*a*) From British Statistical Abstracts. (*b*) In 1893 salt imported was 1.253 tons, value $10. (*c*) Includes 13,234 tons iron plates, value $926,359; sheet iron, 3009 tons, value $511,587; tin plates, 4861 tons, value $589,374. (*d*) Comprised crude, 17,083 metric tons, value $341,652; refined, 42 tons, value $2524.

MINERAL IMPORTS OF SWITZERLAND. (*a*) (IN METRIC TONS; 5f.=$1.)

Year.	Chemical Products	Coal and Coke.		Iron and Steel, Wrought, Pig & Manufactures.		Iron and Steel, Pig & Wrought.		Iron Manufactures.		Mineral Oil, Crude & Refined		Machin'ry and Locomotives.
1890	$4,407,000	993,612	$6,092,800	154,632	$8,576,600	135,363	$5,253,200	19,268	$3,323,400	40,569	$1,763,800	$3,017,200
1891	3,982,600	1,060,624	6,616,400	166,870	8,654,800	145,367	5,254,800	21,503	3,400,000	43,756	1,611,400	3,212,000
1892	4,052,200	985,340	5,827,400	165,771	8,385,000	144,705	4,919,200	21,066	3,465,800	47,956	1,263,200	2,913,000
1893	4,263,228	1,251,851	7,225,824	160,437	.....	160,436	4,819,556	20,662	3,161,570	.....	.....	.....
1894	.....	1,289,660	.....	185,861	.....	185,861	.....	28,702	.....	.....	.....	.....

MINERAL EXPORTS OF SWITZERLAND. (*a*) (IN METRIC TONS.)

Year.	Chemical Products. (*b*)		Dyes, Coal Tar.		Iron Manufactures.		Machinery and Locomotives.
1890.....	7,591	$548,000	1,332	$1,785,000	3,317	$1,047,200	$4,461,400
1891.....	8,289	553,600	1,541	1,958,200	1,957	855,600	4,063,200
1892	9,078	638,900	1,756	2,276,600	2,203	800,600	4,015,600
1893.....	9,848	1,199,057	1,986	2,498,200	2,748	839,639	.....
1894.....	11,500	1,399,000	2,136	2,629,300	2,821	798,160	.....

(*a*) From British Statistical Abstracts, and from figures furnished by the *Direction Générale des Douanes Fédérales*, Berne.
(*b*) Including spirits for technical use; 1893, 3704 tons, $290,772; 1894, 4146 tons.

UNITED STATES.

ACCOUNTS and statistics of the mineral production of the United States will be found in the articles on the various substances in the preceding pages. We give below the mineral imports and exports of the country for the five years ending with 1894:

MINERAL IMPORTS OF THE UNITED STATES. (*a*).

Year.	Aluminum.			Antimony, Crude and Regulus.			Antimony, Ore.				Asbestos.		
	Lbs.	Kilos.	Value.	Lbs.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.	Total Value.	Total.	Unm'n-ufact'd.	Manu-fact'ed.
1890.	2,051	930	$7,062	3,315,659	1,494	$411,960	611,140	277	$29,878	441,838	$257,879	$252,557	$5,342
1891.	3,921	1,779	67,635	3,258,701	1,498	388,850	1,433,531	650	36,232	425,082	358,461	353,589	4,872
1892.	43	19	51	3,950,864	1,792	392,761	192,344	87	7,338	400,099	269,642	262,433	7,209
1893.	7,816	3,546	4,683	.....	.....	.....	116,495	53	4,753	.....	184,999	175,602	9,397
1894.	5,303	2,406	2,524	1,205,752	547	79,265	375,468	170	18,068	97,333	240,029	.....	.....

Year.	Asphaltum.			Barium Sulphate.						Bauxite.			Brass and Mf's of, Value.
	Short Tons.	Metric Tons.	Value.	Man'f'c'd Lbs.	Metric Tons.	Value.	Unm'f'd, Lbs.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.	
1890	73,345	66,538	$223,891	3,125,670	1,417	$16,453	9,629,172	4,367	$13,133	27,503,730	12,475	$46,137	$215,371
1891	14,725	13,358	229,350	3,813,760	1,729	22,041	11,043,200	5,009	4,505	17,936,504	8,135	46,252	277,533
1892	98,581	89,433	336,868	3,111,360	1,411	15,419	6,247,260	2,834	7,418	12,804,253	5,808	57,948	235,782
1893	76,996	69,854	196,314	2,265,121	1,028	11,179	6,681,930	3,031	7,612	11,431,078	5,185	28,217	215,650
1894	106,014	96,202	313,685	1,672,000	759	10,556	3,768,000	1,709	5,270	2,305,783	1,046	6,661	134,356

Year.	Cement.			Nitrate of Soda.			Bicarbonate Soda			Caustic Soda.		
	Barrels.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.
1890	*c*2,567,126	465,779	$3,175,159	293,007,228	132,938	$3,090,900	916,355	416	$16,962	88,345,462	40,075	$1,882,728
1891	*c*2,991,236	542,820	4,411,330	219,712,640	99,663	2,579,930	1,500,663	661	26,936	68,154,226	30,918	1,700,532
1892	*c*2,440,705	442,801	3,378,331	213,456,320	96,815	2,933,174	1,466,595	665	25,874	54,384,120	24,670	1,339,500
1893	*c*2,674,149	485,326	3,470,169	257,626,880	116,890	3,673,537	1,380,426	526	23,136	52,116,492	23,641	1,171,878
1894	*c*2,638,107	478,785	3,396,729	219,824,640	99,739	3,189,084	4,479,524	2,028	63,625	46,544,322	21,118	919,197

Year.	Sal and Ash Soda.			Other Soda Salts.			Nitrate of Potash.			Muriate of Potash.		
	Lbs.	Met. Tons.	Value.	Lbs.	Met. Tons.	Value.	Lbs.	Met. Tons.	Value.	Lbs.	Met. Tons.	Value.
1890	360,521,656	163,562	$4,176,422	21,664,033	9,827	$132,443	13,563,798	6,153	$408,460	63,773,938	28,929	$978,024
1891	347,822,902	157,800	4,509,611	16,226,334	7,360	114,955	15,292,057	6,937	469,591	78,144,810	35,450	1,220,119
1892	361,648,637	164,073	4,698,379	40,954,822	18,580	284,853	13,012,087	5,900	382,771	70,227,971	31,900	1,098,267
1893	348,994,906	158,346	3,983,039	29,850,109	13,544	205,523	13,374,016	6,066	369,274	74,663,116	38,407	1,192,516
1894	319,517,064	144,971	2,658,581	17,667,314	8,016	132,385	9,375,950	4,254	249,842	101,597,074	46,097	1,540,081

Year.	Chromate and Bichromate of Potash.			Chloride of Lime.			Chrome Ore.			Chromic Acid.			Clays or Earths, including Kaolin.		
	Lbs.	Met. Tons.	Value.	Lbs.	Met. Tons.	Value.	Long Tons.	Met. Tons	Value.	Lbs.	Kil's	Value	Long Tons.	Met. Tons.	Value.
1890	1,304,185	592	$113,613	105,696,046	47,745	$3,314,548	4,353	4,423	$57,111	.....	.....	$634	53,388	54,242	$367,233
1891	755,254	343	53,897	108,880,831	49,389	1,632,127	4,560	4,633	108,764	634	287	203	62,598	63,606	471,785
1892	1,193,972	541	94,708	109,888,561	49,846	1,962,084	4,930	5,009	55,589	772	347	204	75,283	76,495	605,022
1893	979,706	444	78,981	98,618,147	44,735	1,843,410	6,354	6,456	58,629	3,708	1,682	641	73,387	74,586	564,547
1894	1,483,762	673	125,796	96,256,251	43,673	1,697,038	3,470	3,525	38,364	6,680	3,030	1,045	78,698	79,983	616,506

Year.	Coal.					Coke.			Cobalt Oxide.		
	Anthra	Bitumin.	Total.	Total.	Total.						
	Short Tons.	Short Tons.	Short Tons.	Metric Tons.	Value.	Short Tons.	Metric Tons.	Value.	Lbs.	Kilos.	Value.
1890..	19,316	939,168	958,484	869,537	.....	20,808	18,877	$101,757	33,338	15,121	$63,202
1891..	16,676	1,525,972	1,542,648	1,399,490	.....	50,753	46,043	223,184	35,483	16,094	60,630
1892..	.....	1,144,499	1,144,499	1,038,290	$3,747,140	24,482	22,210	86,350	32,833	14,775	60,067
1893..	.....	1,108,538	1,108,538	1,005,933	3,620,368	33,165	30,080	99,683	28,164	12,775	41,105
1894..	.....	1,244,330	1,244,330	1,128,156	3,829,807	29,137	26,427	70,358	24,020	10,900	29,857

Year.	Fine Copper in Ore.			Copper Ingots, Old, etc.			Manuf's Value.	Total Value.	Cryolite.		
	Lbs.	Metric Tons.	Value.	Value.	Metric Tons.	Value.			Long Tons.	Met. Tons.	Value.
1890....	6,017,041	2,729	$394,864	$663,676	201	$57,014	$127,527	$579,405	7,129	7,244	$95,405
1891....	11,690,312	5,303	875,855	3,154,557	1,431	276,263	513,611	1,655,729	8,296	8,430	76,350
1892....	8,107,582	3,677	499,574	1,724,772	782	131,608	96,627	727,809	8,155	8,286	73,847
1893....	7,723,387	3,504	467,988	5,536,690	2,510	488,710	83,752	1,040,450	9,574	9,728	126,688
1894....	3,870,769	1,756	297,118	2,289,324	1,039	170,368	65,256	533,742	8,540	8,676	142,494

Year.	Earthen, Stone and Chinaw'e	Emery, Grains.			Emery, Rock.			Other M'f'res.	Total Value.	Guano.		
		Lbs.	Met. Tons.	Value.	Long Tons.	Metric Tons.	Value.			Long Tons.	Met. Tons.	Value.
1890....	$7,724,289	534,968	243	$30,382	3,867	3,929	$97,939	5,046	$123,367	4,981	5,061	$60,135
1891....	8,752,163	90,658	41	3,729	2,530	2,571	67,573	.....	71,302	11,937	12,129	199,044
1892....	8,987,111	566,448	257	22,586	5,280	5,365	95,625	2,412	120,623	3,073	3,122	46,014
1893....	8,769,778	516,953	234	20,073	5,066	5,147	103,875	3,819	127,767	5,951	6,045	97,890
1894....	6,978,148	597,713	271	18,645	1,642	1,668	51,487	1,830	.....	5,246	5,332	102,423

Year.	Iron Ore.			Iron, Pig, Scrap, Spiegel, and Ferromanganese.			Bar Iron.			Castings, Boiler, Hoop, Sheet, Taggers.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Met. Tons.	Value.
1890	1,246,830	1,266,904	$2,854,118	191,232	194,310	$4,535,526	24,034	24,421	$1,002,480	*a*30,218	30,708	*d*$1,515,225
1891	912,864	927,561	2,456,546	67,179	68,260	1,432,455	18,099	18,390	770,858	*d*12,752	12,958	*d*781,557
1892	806,585	819,571	1,795,644	99,348	100,947	2,023,428	19,728	19,594	776,927	71,756	72,909	3,195,684
1893	526,951	535,435	906,687	60,667	61,644	1,321,899	14,896	15,138	603,985	76,647	77,878	3,276,537
1894	167,307	169,281	267,241	17,962	18,250	451,348	9,228	9,378	377,397	.....	.....	.....

Year.	Steel Ingots, Billets, Blooms, Slabs, Sheets, etc.			Tin and Terne Plates.			Rails.			Total.	Lead, Ore and Dross.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Met. Tons.	Value.	Long Tons.	Met. Tons.	Value.	Value.	Lbs.	Met. Tons.	Value
1890	28,636	29,097	$1,578,286	329,435	334,739	$23,670,158	204	207	$5,035	$44,540,413	493,463	224	$12,947
1891	34,685	35,243	1,673,214	327,868	333,147	25,900,305	253	257	8,405	41,983,626	105,898	48	6,721
1892	30,586	31,081	1,591,092	268,472	272,793	17,102,487	347	352	10,607	33,882,447	127,873	58	9,932
1893	26,868	27,300	1,293,834	253,485	257,564	15,559,423	2,888	2,922	57,584	29,667,364	(*c*)	.....	.....
1894	9,494	9,649	809,184	215,067	218,581	12,053,167	300	304	4,292	.....	.....	.....	.....

Year.	Lead, Pig, Bars, and Scrap.			Sheets, Pipe, and Shot.			Manufacturer's N. E. S.	Total Values. (*f*)
	Lbs.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.		
1890.....	19,336,233	8,771	$593,671	68,314	31	$3,338	1,210,387	$1,821,837
1891.....	3,392,562	1,539	104,184	334,179	151	12,406	2,744,122	2,867,633
1892.....	1,549,771	749	110,593	90,153	40	6,207	.....	4,569,176
1893.....	3,621,525	1,643	141,405	56,678	26	2,914	.....	6,608,639
1894.....	39,168,529	17,771	895,496	44,080	20	2,050	.....	4,228,796

Year.	Manganese.						M'ble and Stone, & Ma'f's of.	Metals, Comp's & Ma'f's of.	Mica. (*r*)	Mineral Subst's N. E. S.	Nickel.	Oil, Mineral.		
	Ore.			Manufactured.										
	Long Tons.	Met. Tons.	Value.	L'ng Tons	Met. T'ns	Value	Value.	Value.	Value.	Value.	Value.	Gallons.	Liters.	Value.
1890	33,998	34,545	$509,704	156	158	$7,196	$1,338,177	$5,616,609	$146,975	$106.999	$376,279	627,039	2,373,341	$45,352
1891	28,624	29,087	371,594	201	204	9,024	1,312,856	7,445,640	110,442	183,175	321,163	1,362,288	5,156,259	62,222
1892	58,364	.....	830,046	208	.....	10,305	1,525,271	6,470,918	100,846	275,615	426,817	909,885	3,443,913	49,487
1893	67,717	68,807	860,832	(*g*)	.....	.....	1,637,165	6,325,307	120,864	261,646	384,628	523,800	1,842,583	31,801
1894	44,655	45,384	432,561	.....	.....	.....	1,197,987	3,768,116	126,184	139,688	45,927	152,870	578,659	27.266

Year.	Ozokerite.			Paints and Colors.	Palladium, Manufactured		Platin'm Man'factured.		Platinum, Ore, Sponge, Plate.		Platinum, Vases, Retorts, etc.		Precious Stones.	
	Lbs.	Met. Tons	Value.	Value.	Weight, Grams.	Value	Kil.	Val.	Kilos.	Value.	Kilos.	Value.	Rough &Uncut	Cut.
1890	1,669,241	757	$142,333	$1,452,509	1,181.13	$1,037	.75	39	2,563.02	$702,093	322.30	$159,057	$513,611	$12,540,646
1891	1,869,241	847	149,539	1,378,970	.....	.....	.012	49	2,204.35	972,989	66.59	26,228	975,772	11,769,663
1892	1,250,000	567	150,000	1,366,844	.....	.....	.....	.....	1,774.96	505,852	170.63	53,763	1,032,869	13,427,774
1893	1,744,905	792	133,111	1,294,857	.....	.....	....	1,412	1,993.20	538,478	.....	69,823	802,075	10,022,371
1894	(*f*)	.....	.....	1,045,251	.....	5	....	.....	1,670.90	485,272	.....	88,195	839,806	6,710,472

Year.	Pyrites.			Salt.			Sulphur, Crude.			Flowers, Sulphur.		
	Long Tons.	Metric Tons.	Av. Sulph. % Contents.	Lbs.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Met. Tons.	Value.
1890.....	115,000	116,852	43	527,835,772	239,322	$932,905	131,096	133,206	$2,147,481	*o*188	191	$5,139
1891.....	130,000	132,093	44	463,455,263	210,220	793,115	116,971	118,854	2,675,192	206	209	6,762
1892.....	210,000	213,381	43	456,613,733	207,213	768,415	100,721	102,342	2,189,307	158	160	5,439
1893.....	194,934	198,072	(*h*)	332,939,120	151,515	569,626	107,601	109,333	1,903,191	241	245	5,746
1894.....	163,546	590,905	25	421,225,027	191,118	643,167	124,467	126,500	1,734,643	165	168	4,145

Year.	Refined Sulphur.			Block Tin.			Zinc. (*i*)				
							Sheet, Block, Pig, and Old.			Man'f's Net Value.	Total Value.
	Long Tons.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.		
1890.	10	10	$299	33,821,319	15,341	$6,869,645	2,112,626	958	$107,017	$53,469	$160,486
1891.	10	10	1,997	41,146,123	18,663	8,091,363	814,218	369	41,369	18,424	59,793
1892.	26	27	4,106	46,821,958	21,238	9,415,889	*x*410,896	186	23,307	22,709	46,016
1893.	43	44	1,017	40,184,556	18,228	8,007,292	*x*425,998	193	22,931	20,756	43,687
1894.	41	42	1,207	22,745,958	10,320	5,944,065	*x*512,932	233	17,271	12,342	29,613

(*a*) From *Summary Statements of the Imports and Exports of the United States* and *Mineral Resources of the United States*, and several figures for 1893 and 1894 kindly furnished by Mr. J. V. Whitney, acting Chief of Bureau of Statistics. When not otherwise expressed, all years are calendar. All fiscal years end June 30. The following substances not given in the above table, were imported in 1893: Bromine, 780 lbs., $234; plaster of paris, unground, 164,300 long tons, $180,263; ground, 1368 long tons, $22,643; calcined, 2565 long tons, $18,316; ocher and ochery earths, dry, 6,126,006 lbs., $53,943; ground in oil, 51,804 lbs., $3321; spiegeleisen and ferromanganese, 37,457 long tons, $879,731; quicksilver, 30,191 lbs., $12,507; talc, 2,720,528 lbs., $12,825. Further imports in 1894: Bromine, 20 lbs., $11; ocher and ochery earths, dry, 4,937,738 lbs., $45,276; ground in oil, 22,387 lbs., $2,100; plaster paris, unground, 162,500 short tons, $179,237; ground, 340 short tons, $5,966; calcined, 1687 short tons, $10,857; quicksilver, 7 lbs., $6; talc, 1,242,171 lbs., $6,815; borax, 1,029,786 lbs., $39,256.

(*b*) In 1891 manufactured only; in 1893, 3286 lbs., $2168, crude and alloys of any kind in which aluminum is the component material of chief value; in 1892, $2244, and in 1893, $3301, manufactures not specially provided for.

(*c*) Custom-house returns for these years are given in pounds, which are reduced to barrels of 400 lbs., for convenience of comparison. (*d*) Six months.

(*e*) Amount of lead contained in silver ore was 58,069,401 lbs., $985,324; that contained in other ores and dross, 13,686 lbs., $354; in 1893 were imported: Litharge, 42,582 lbs., $1,310; red lead, 832,152 lbs., $26,885; white lead and white paint containing lead, 682,912 lbs., $33,973; in 1894, lead ore and dross, 33,020,250 lbs., $437,999.

(*f*) Value of lead in ores from Mexico included, which amounted to 18,124 tons in 1890, 23,867 tons in 1891; 39,608 tons in 1892; 29,370 tons in 1893. (*g*) Not enumerated. (*h*) Containing above 25% of sulphur.

(*i*) The imports of zinc oxide were, in 1890, dry, 2,631.458 lbs; in oil, 102,298 lbs.; in 1891, dry, 2,839,351 lbs.; in oil, 128,140 lbs.; in 1894, dry, 3,371,292 lbs.; in oil, 59,291 lbs.

MINERAL EXPORTS OF DOMESTIC PRODUCE OF THE UNITED STATES. (*a*) (IN TONS OF 2240 LBS.)

Year.	Asbest's	Brass and Man'frs	Cement.		Chemicals Drugs, Medicines.	Coal. Anthra. Short Tons.	Coal. Bitum. Short Tons.	Total. Short Tons.	Total Metric Tons.	Copper Ore. (*c*)		
	Value	Value.	Bbls.	Value.	Value.					Lbs.	Metric Tons	Value.
1890	.....	.....	$86,963	$152,295	.....	889,361	1,434,914	2,324,275	2,108,582	54,116,160	24,547	$4,413,067
1891	$17,847	.....	83,607	130,371	.....	967,181	1,807,202	2,774,383	2,516,920	86,477,440	39,225	6,565,620
1892	4,800	$438,486	79,179	137,167	$6,618,827	851,639	1,645,686	2,497,325	2,265,573	113,113,616	51,308	6,479,758
1893	17,134	741,317	93,485	154,461	7,002,879	1,334,287	2,324,591	3,658,878	3,320,216	93,527,950	42,424	4,257,128
1894	5,762	779,875	*b*108,000	165,809	7,722,532	1,440,625	2,195,716	3,636,341	3,299,765	9,748,480	4,422	440,129

Year.	Copper, Pig, Sheet, Old.			Manufact'r's Value.	Total Value.	Earthen, Chinaw'e	Glassware.	Gold and Silver in Coin and Bullion. (*d*)		Gold and Silver in Ores. (*e*)	
	Lbs.	Met. Tons.	Value.			Value.	Value.	Gold.	Silver.	Gold.	Silver.
1890	10,971,899	4,977	$1,365,379	$139,949	$5,918,395	.....	.....	$24,063,074	$26,539,789	$32,094	$1,126,697
1891	(*f*)69,279,024	31,425	8,844,304	293,619	15,703,543	.....	.....	79,086,581	27,692,879	100,918	1,090,511
1892	(*f*)30,515,736	13,742	3,438,048	245,064	10,162,870	$245,731	$938,154	76,532,056	35,975,834	9,262	1,592,934
1893	(*f*)138,984,128	63,043	14,213,378	464,991	18,935,497	151,308	971,503	79,775,820	46,288,721	(*j*) 190,849	190,846
1894	162,393,000	73,681	15,324,925	378,040	16,143,094	138,289	917,519	101,819,924	47,044,205	(*j*) 149,501	149,501

Year.	Iron, Pig.			Iron, Bar.			Iron, Boiler, Band, Hoop Scroll, and Sheet.			Iron, Steel Ingots, Bars, Sheets, and Wire.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons	Value.
1890..	16,341	16,604	266,107	1,068	1,085	$97,317	609	619	$48,168	10,721	10,849	$886,244
1891..	14,945	15,186	258,000	1,341	1,363	85,382	506	514	34,019	12,516	12,718	940,375
1892..	15,427	15,675	282,290	963	979	60,463	31	31	1,762	15,291	15,537	1,027,541
1893..	24,587	24,989	379,437	1,842	1,872	94,239	255	259	10,467	17,079	17,354	1,033,757
1894..	24,480	24,872	309,222	3,195	3,248	130,374	99	101	5,380	27,716	28,159	1,355,705

Year.	Iron—*Continued.* Rails.				Lead, Man'fs.	Marble, Stone & Man'fs.	Mica.	Nickel. (*a*)	Petroleum(1=1000 in quantities and value					
									Crude.		Naphtha.		Illuminating.	
	Long Tons.	Met. Tons.	Value.	Total Value.	Value.	Value.	Value	Value.	Gals.	Value	Gals.	Value	Gals.	Value.
1890	16,948	17,221	$577,916	$27,000,134	$181,030	.....	.....	$471	96,573	$6,535	12,462	$1,051	550,873	$39,826
1891	11,239	11,420	363,488	30,736,442	173,887	.....	.....	184,782	96,723	5,366	11,424	868	531,445	34,880
1892	7,982	8,110	256,325	27,900,862	154,375	$765,165	$250	197,763	104,397	4,696	16,393	1,038	589,418	31,827
1893	19,876	20,194	595,988	30,159,363	508,090	964,616	480	378,577	115,091	3,966	16,344	1,004	711,828	31,796
1894	13,556	13,773	356,186	29,943,729	497,993	1,009,704	659	495,218	114,958	4,673	14,915	912	733,924	30,287

(*a*) From July 1, 1891, nickel oxide and matte are included.

Year.	Petroleum—*Continued.*						Platinum.				Quicksilver.		
	Lubricating.		Res. & All Oth's		Paraffine.		Manufactures.		Scrap.				
	Gals.	Value	Gallons	Value.	Lbs.	Value.	Kilos.	Value.	Kilos.	Value.	Lbs.	Metric Tons.	Value.
1890	32,091	$4,767	1,831	$92	59,693	$2,920	.....	.....	116.90	$45,835	.....	.....	.....
1891	32,210	5,000	1,003	61	65,076	3,979	.....	.....	43.59	12,900	.....	.....	.....
1892	34,027	5,131	403	38	69,876	4,160	.....	$9,000	.....	.....	269,104	122	$133,626
1893	35,645	5,069	543	35	99,061	4,553	.....	23,953	.....	.....	1,272,271	577	542,410
1894	39,946	5,368	119	10	85,125	3,277	.....	6,992	.....	.....	1,102,187	500	397,528

Year.	Salt.			Tin, Man'f's Value.	Zinc Ore and Oxide.			Zinc Sheets, Pigs, Bars.			Manuf's Value.	Total Value.
	Lbs.	Metric Tons.	Value.		Lbs.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.		
1890	5,927,022	2,235	$30,079	.....	8,664,320	3,930	$195,113	3,925,584	1,780	$126,291	23,587	$344,991
1891	5,242,280	2,378	29,519	.....	13,071,840	5,935	149,435	4,294,656	1,948	278,182	38,921	466,538
1892	.....	.....	.....	$204,429	2,058,560	.....	41,186	12,494,335	5,667	669,549	166,794	877,529
1893	.....	.....	.....	258,449	109,760	50	1,271	7,446,934	3,379	413,673	224,787	638,460
1894	.....	.....	.....	301,503	.....	.....	5	3,607,050	1,610	144,074	99,406	243,480

(*a*) From *Summary Statements of the United States* and from *Mineral Resources of the United States.*
(*b*) Includes lime.
(*c*) Ore, so called, is mostly matte, and during 1891 and 1892 matte exports averaged about 55% fine copper.
(*d*) Total exports of coin and bullion; that is, includes both domestic and foreign, not elsewhere specified.
(*e*) Only approximately correct. The Bureau of Statistics reports only the value of silver ores exported, but a much larger amount of silver leaves the country in copper matte which is classified as copper ore and no record is kept of its silver contents. In the above table the value of silver in copper matte so far as could be ascertained from the Director of the Mint has been added to the value of silver ores, the values being calculated at the commercial rate each year. The gold in copper matte exported is not included in the exports of gold given in the above table.
(*f*) Shoots are not included these years, but are reported with manufacturers.

MINERAL EXPORTS OF FOREIGN PRODUCE FROM THE UNITED STATES. (*a*)

Year.	Asphaltum or Bitumen (Crude).			Brass and Mf's of.	Cement.			Chemicals.								
								Salts of Potash. (*b*)			Chloride of Lime.			Nitrate of Soda.		
	Long Tons	Met. Tons	Value	Value.	Lbs.	Met. Tons	Value.	Lbs.	Kilos.	Value	Lbs.	Kilos.	Val.	Long Tons	Met. Tons	Value.
1890	.....	.....	.....	$1,072	3,533,000	1,603	$14,219	31,055	14,081	$627	1,900	862	$54	88	89	$4,478
1891	398	404	$4,530	5,097	4,055,002	1,839	17,297	.....	.....	.....	.....	.....	.....	104	106	2,984
1892	84	85	2,513	8,702	8,614,537	3,907	32,371	.....	.....	.....	.....	.....	.....	214	217	8,355
1893	378	384	4,838	3,430	5,710,675	2,590	20,202	109,778	49,794	4,922	2,566	1,164	231	2,428	2,467	105,624
1894	502	510	9,211	6,979	3,889,928	1,765	15,072	719,861	326,529	14,436	19,943	9,046	550	549	558	19,819

Year.	Chemicals—*Continued.*									Clays or Earths of All Kinds, including China Clay.			Coal, Bituminous.		
	Caustic Soda.			Sal Soda and Soda Ash.			All Other Salts of Soda								
	Lbs.	Met. Tons	Value.	Lbs.	Kilos.	Value.	Lbs.	Kilos.	Value	Long Tons.	Met. Tons.	Value	Long Tons.	Met. Tons	Value
1890	1,832,563	831	$40,188	74,153	33,635	$1,324	56,209	25,344	$683	41	41	$332	843	856	$9,689
1891	2,693,103	1,222	72,382	84,152	37,944	1,150	76,640	34,557	1,162	52	53	578	1,239	1,259	12,005
1892	1,408,986	639	37,872	46,876	21,266	725	63,591	28,844	942	60	61	514	127	127	1,310
1893	1,760,856	799	45,724	193,556	87,795	2,519	68,759	31,189	1,135	175	178	1,531	9	9	126
1894	2,929,473	1,329	66,017	101,886	46,214	1,305	131,118	59,474	5,648	92	93	616	877	891	4,934

Year.	Copper.							Earthen, Stone and China-ware.	Fertilizers.						Other Fert'z's
	Copper Ore. Fine Copper Therein.			Pigs, Bars, Ingots, Old, & Other Unm'fd			Mnf'es of.		Guano.			Phosphates, Crude or Native.			
	Lbs.	Met. Tons	Value.	Lbs.	Met. Tons	Value.	Value.		Tons.	Met. Tons.	Val.	Long Tons.	Met. Tons.	Value	Value.
1890	1,636,058	742	$87,494	233,824	106	$20,368	$28,631	$18,562	1	1	$45	.....	.....	.....	$69,720
1891	2,082,708	945	78,514	534,949	243	43,637	15,185	19,144	.....	.....	.....	115	117	$1,150	52,190
1892	707,739	321	38,088	1,274,410	578	97,364	6,711	11,458	1	1	44	.....	.....	.....	.....
1893	1,012,267	459	81,187	1,007,554	457	80,236	20,546	15,657	6	6	295	.....	.....	.....	222
1894	235,140	107	20,008	1,150,169	522	78,544	13,056	19,541	106	108	1,620	.....	.....	.....	8

Year.	Glass and Glass ware.	Gold-bearing Ores, N. E. S.	Gold and Silver, Manufactures of.	Graphite.			Iron Ore.			Iron and Steel, and Tin Plate, Etc.					
										Pig Iron.			Scrap Iron and Steel, fit only to be remanufact'd.		
	Value.	Value.	Value.	Long Tons.	Met. Tons.	Value	Long Tons.	Met. Tons	Value	Long Tons.	Met. Tons.	Value	Long Tons.	Metric Tons.	Value.
1890	$17,115	$34	$5,808	.....	.....	.....	.....	.....	.....	451	458	$6,363	657	667	$6,932
1891	6,814	6,484	39,927	36	37	$2,500	.....	.....	.....	226	230	2,980	370	376	3,539
1892	12,761	13,272	69,314	.....	.....	.....	31	31.5	$211	133	135	1,544	340	345	6,164
1893	11,366	17,057	17,308	164	166	5,615	.....	.....	.....	35	36	350	117	119	1,800
1894	26,509	.....	55,065	43	44	4,371	.....	.....	.....	78	79	922	1,526	1,550	18,422

Iron and Steel, and Tin Plate—*Continued.*

Year.	Bar Iron, Rolled or Hammered.			Railway Bars of Iron or Steel, or in Part of Steel.			Ingots, Blooms, Slabs, Billets and Bars of Steel, and Steel in forms, N. E. S.			Steel Plate and Taggers, Wire Rods, Wire and Wire Rope, and Structural Iron or Steel.		
	Lbs.	Metric Tons.	Value	Long Tons.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.
1890	56,006	25	$888	.....	.....	.....	.....	.....	.....	360,049	164	$10,587
1891	76,896	35	1,151	19	19	$462	5,516	2	$485	412,620	187	12,306
1892	93,883	43	1,268	100	102	2,433	39,794	18	1,938	296,023	132	9,525
1893	7,067	3	148	1,243	1,263	24,297	181,111	82	10,232	336,682	153	8,503
1894	72,160	32	1,606	546	555	10,449	64,650	29	8,094	211,032	96	4,870

Year.	Tin Plates, Terne Plates, and Taggers Tin.			Manufactures of.	Lead and Manufactures of.	Marble and Stone, and Manufactures of.	Metal Compositions and Manufactures.	Mineral Substances.	Oil, Mineral.			Paints and Colors.
	Lbs.	Metric Tons.	Value.	Value.	Value.	Value.	Value.	Value.	Gals.	Liters.	Value	Value.
1890	917,462	416	$28,294	$88,474	$737,489	$3,338	$170,934	$200	.....	.....	.....	$6,329
1891	1,164,742	528	41,637	110,324	1,743,739	6,436	96,737	1,114	40	151	$17	5,626
1892	548,134	349	16,433	83,260	3,348,124	1,892	105,904	16	310	1,173	247	3,492
1893	1,256,393	560	36,542	164,721	5,478,182	10,736	91,624	2,572	4,776	18,077	1,045	10,271
1894	920,426	418	29,402	175,727	3,316,481	18,832	270,557	7,196	40,350	152,725	12,291	9,180

Year.	Platinum, Unmanufact'ed.			Precious Stones.	Salt.			Silver-bearing Ores.	Sulphur or Brimstone (Crude).			Tin in Bars, Blocks, Pigs, or Grain, or Granulated.			Zinc or Spelter, M'f'res
	Lbs	Kilos.	Value	Value.	Lbs.	Met. Tons.	Value	Value.	Long Tons.	Met. Tons.	Value	Lbs.	Met. Tons.	Value	Value.
1890	....	.....	.....	$36,716	4,034,292	1,830	$5,157	$74,214	.....	.....	.....	.....	.....	.....	$192
1891	....	.....	.....	33,433	1,096,400	497	1,270	212,624	50	51	$1,545	44,900	20	$2,000	778
1892	1	½	$83	5,956	3,542,113	1,607	4,687	305,640	.....	.....	3	55,532	25	11,212	44
1893	1	½	35	311,660	1,155,217	524	2,897	69,027	65	66	1,360	310,266	141	63,580	570
1894	....	.....	.....	7,071	4,693,678	2,095	5,618	62,584	.....	.....	.....	168,484	76	26,537	216

(*a*) From *Summary Statements of the Imports and Exports of the United States.* (*b*) This includes chlorate of potash, muriate of potash, nitrate of potash, and all other potash.

Alabama and Georgia.

By William M. Brewer.

The States of Georgia and Alabama can best be treated together, since the geological formations which contain minerals in workable quantities extend continuously across both States, and there is a marked similarity in the methods of mining, seasons of active operations, and general rate of wages prevailing. We find the same Crystalline formation extending from northeastern Georgia into northeastern Alabama; and overlying this on the northwest the Paleozoic formations extending across northwestern Georgia into northeastern Alabama.

The Crystalline formations, including the true crystalline rocks of the Archean period, with the schists and slates, contain the gold-bearing ores as well as pyrites, mica, asbestos, corundum, soapstone, beryl, tantalite, crystalline dolomite, feldspar, and kaolin, all of which have been mined on a more or less extensive scale.

The Paleozoic formations, including the Cambrian and Knox-Dolomite, part Silurian and Cambrian, contain the limestones, marble, limonite, or brown iron ore, bauxite, manganese, baryta, and ochers.

The red hematite iron ore of the Clinton, or Red Mountain, division of the Silurian formation, which occurs in Alabama in extensive deposits in Jefferson, Blount, St. Clair, Etowah, and in other counties less extensively, is also found in the counties of Dade, Walker and Catoosa, Georgia. The coal measures of the Carboniferous period, which occur extensively in Alabama north of latitude 33°, extend into Georgia in one county only—that of Dade, in the extreme northwestern corner. There is also an occurrence of limonite, or brown iron ore, in Lauderdale and Franklin Counties, Alabama, overlying the Subcarboniferous formation, which is confined to that State. In the following review the different minerals are treated in alphabetical order.

Asbestos.—Except in White County, Georgia, where the Sall Mountain Asbestos Company is operating, no active mining is being carried on. Some prospecting has been done in both Georgia and Alabama, but the grade of the product was not sufficiently good to command a market. Very extensive deposits of low-grade material occur in Coweta, Troup, Heard, Carroll, and White Counties in Georgia, as well as in Tallapoosa County, Alabama.

Barytes.—A few carloads of this mineral were shipped from Bartow County, Georgia, to New Haven, Conn., during 1894, as samples. These shipments were of the lumps in the crude state, and netted the shipper about $3 a ton f. o. b. Quite extensive beds of barytes occur in the vicinity of Cartersville, also in Cleburne, Bibb, Shelby, and Jefferson Counties in Alabama. So far the only shipments have been the samples from Cartersville, where the erection of a plant for grinding the barytes is under contemplation.

Bauxite.—The industry of mining bauxite has been carried on more extensively in Alabama than in Georgia during the year 1894. The chief producers have been the mines in Bartow County, Georgia, and in Dykes district, Cherokee County, Alabama. The total production in the State of Alabama for 1894, from monthly returns furnished by the shippers, is given below. The total yearly out-

put from both States is compared with that of each year since shipments began in 1889. The figures are in tons of 2240 lbs.:

1894.	Tons.	1894.	Tons.		Tons.
January	715	July	874	Total, 1894	10,329
February	137	August	662	" 1893	11,028
March	247	September	1,079	" 1892	9,800
April	604	October	1,262	" 1891	3,900
May	836	November	792	" 1890	1,850
June	1,046	December	433	" 1889	728

The production of bauxite in the State of Georgia in 1894 was 2042 long tons.

In THE MINERAL INDUSTRY for 1894, Professor McCalley, Assistant State Geologist for Alabama, published an able and exhaustive review of the conditions of the bauxite mining industry, and comparatively the same general conditions have marked the industry during 1894. No new discoveries have been reported during 1894; the same companies are engaged in shipping; and, except that the mines have been more extensively developed, no changes have taken place of importance. The old standard of wages ($1 per day) has been maintained by the Republic Mining and Manufacturing Company in the Dykes district; but the Southern Bauxite Company, in the same district, has reduced the wages of its employés 10%. The last-named company has also erected a drying furnace in order to thoroughly eliminate the water carried by the ore in combination. Heretofore the only process resorted to for drying this ore has been that of spreading it under sheds. Apparently the supply of ore is practically inexhaustible in the mines which are the largest producers. The Southern Bauxite Company has sunk a test shaft 65 ft. below the floor of their present open cut at the Warwhoop bank, and have not reached the bottom of the bauxite. In fact, deeper mining in all the banks in the Dykes district has demonstrated that the same conditions exist. The values vary according to the grade of the ore and location of the market, and have varied but little in average from the quotations in Professor McCalley's article referred to. The same may be said as to cost of mining and rates of freight.

According to State Geologist Eugene A. Smith, the geological horizon of the bauxite is about the same as that of the greater part of the brown ores of iron, and in Cherokee County the iron ore banks are in some cases coterminous with those of bauxite. The remarkable degree of purity of the Alabama bauxite makes it an article which will probably in the near future be in request as an ore of the metal aluminum.

Beryl.—Some quite handsome specimens were found at various times during the past year in Coosa County, Alabama, of which several were cut in New York, and set as gems.

Coal.—The coal of Alabama, according to the State Geologist, is distributed in three separate areas, known as the Warrior, the Cahaba, and the Coosa fields. In each we find some 5000 ft. thickness of measures, including about 50 seams of coal; but in 1892 about 50% of all the coal mined in Alabama came from the Pratt seam, 25% from the Newcastle seam, both in the Warrior field; 15% came from two seams of the Cahaba field, and 10% from other seams of the Warrior

and Coosa fields. The production in 1893 was 5,170,042 tons, but this fell off in 1894 to 4,381,395 tons as a result of a strike among the miners lasting for several months of the summer. The coal is all bituminous, and as a rule well adapted for the production of coke, of which 1,063,902 tons were made in 1893, and 924,000 tons in 1894.

Corundum.—Beyond some prospecting in northeast Georgia no activity has been manifested during the past year in corundum mining.

Crystalline Dolomite.—An extensive bed of pure white dolomite occurs in the southern portion of the crystalline rock region, extending from Harris County, Georgia, across the Chattahoochee River into Lee County, Alabama. At Chewacla, in Lee County, it is quite extensively quarried and burned, producing a lime of superior quality. These works have been in active operation for upward of 50 years, and produce about 100,000 barrels of lime annually from four kilns.

Feldspar.—During 1894 the only shipments of feldspar made were from Coosa County, Alabama. The shipments were quite limited in quantity, the feldspar being used experimentally for the bedding of coal-washing jigs. The Standard Coal and Coke Company of Tuscaloosa County used this feldspar successfully, paying therefor $10 per ton f. o. b. at shipping point. The distance from market, low price, and limited demand by the porcelain manufacturers of the East, have deterred our miners in the past from prospecting for feldspar; but if it comes into general use among the coal washers in future, an incentive to search for the mineral will be created.

Kaolin.—The industry of mining kaolin is not actively carried on anywhere in either Georgia or Alabama. There occur, associated with the occurrences of mica, several very extensive beds of a superior grade, samples from which have been tested in the Eastern plants. Remoteness from railroad transportation, low price at the factories, high freight rates, and general lack of knowledge as to location of works using this clay, have been the reasons for the undeveloped condition of the deposits, which occur chiefly in Carroll, Heard, Coweta, and Troup Counties in Georgia, and Cleburne, Randolph, Clay, and Tallapoosa Counties in Alabama.

Gold.—Although the production of gold in these States has not materially increased since 1893, in which year Georgia reported $97,200 and Alabama about $10,000, yet progress has been made in the gold belt, the results of which will be manifested during the present year. Probably in no year in the past has so much experimental work by experts in mining and metallurgy been performed as during 1894 in both Georgia and Alabama.

The Creighton Mining and Milling Company in Cherokee County, Georgia, has abandoned the cyanide process for treatment of their sulphurets and substituted barrel chlorination as practiced by Professor Theis at the Haile mine in South Carolina. Professor Theis' son is at present superintendent for this company. The depth of the workings has been increased 50 ft. during the past year, making a total depth of 475 ft. on an incline, or about 400 ft. vertically. The ore yields an average of $8.50 per ton, and it is claimed that 98% of this value is saved by amalgamation followed by concentration and barrel chlorination of the sulphurets. The plant is running up to its capacity of 50 tons daily, and the cost of mining and treatment is about $3 per ton, including all dead work, office expenses and superintendent's salary.

The Latham mine, also in Cherokee County, Georgia, has recently been purchased by George Thomas Chester, of Buffalo, N. Y., who proposes to operate the property actively after the most approved modern methods of treatment of the ore.

The Hand-Barlow Company of Dahlonega, Ga., is operating only a portion of its property. This company is apparently awaiting the result of experiments being made by the vice-president, Arthur Weld, who removed from Colorado some months since to conduct these experiments, and superintend the erection of improved plants and pumping machinery on the individual property of Christian Wahl of Milwaukee, who is also president of the Hand-Barlow Company. The properties on which these improvements have been made are the Hedwig and Findley, which are to be actively operated on a more extensive scale in future than has been general in this district in the past.

The Chestatee Placer Company's plant, near Dahlonega, will be working on the bed of the Chestatee River during the coming year, the canal in which to turn the waters of that river being nearly completed. This enterprise has up to the present time cost about $30,000, and nearly all the work performed has been dead work, as but very little pay gravel was encountered in the construction of the canal, contrary to the expectation of the company. The property, consisting of one mile of the river bed and 250 acres of placer ground, was purchased about two years since; an electric plant was erected, and the water power improved, on the strength largely of traditions regarding the richness of the diggings in the past. The truth, or otherwise, of these traditions will be practically demonstrated during the coming year. A Bucyrus dredge-boat has been operated on the Chestatee River during a portion of the past year, but with what results cannot be ascertained at present.

The North Georgia Agricultural College proposes during the coming year to operate the Calhoun mine, which has remained idle for several years.

The Clopton mine, in the Villa Rica district in Carroll County, Georgia, was sold in December, 1894, to a Boston syndicate, which proposes to work it systematically.

Cherokee and Paulding Counties have both been pretty thoroughly prospected during the past year, but none of these prospects have yet developed into producers.

The Camille mine, in Haralson County, Georgia, on which $75,000 worth of machinery was erected several years ago, was unwatered and prospected by Captain Fisher, an Arizona mining expert, during the past year, but abandoned because of unsatisfactory results.

In Alabama, the Silver Hill mines in Tallapoosa County have been the only regular producers. These have been worked at a small profit, about $2 a ton being saved by amalgamation in a 15-stamp mill, at a cost of not to exceed $1.50 a ton. This ore is so interstratified with graphitic slate that no attempt is made to separate the material as it is quarried in the open cut at the mine; consequently a large percentage of the assay value cannot be saved because of the affinity of graphite for mercury. Experiments are being conducted to eliminate the graphite.

Birmingham and New York capitalists, with T. H. Aldrich, formerly general

manager of the Tennessee Coal, Iron and Railroad Company, are prospecting the Hog Mountain property in Tallapoosa County, which has been in litigation for several years past; the suit was recently decided. No results have yet been made public.

Considerable prospecting and testing have been done during the past year in the Arbacoochee district in Cleburne County. The general tendency has been to do deeper mining, and to prospect locations with a view to selling or to organizing companies as soon as opportunity offers.

Pinetuckey, in Randolph County; Lucky Joe, Mossback, Anna Howe, Crown Point, in Cleburne County; Franklin and California, in Clay County, on all of which small mills have been erected in the past, have been non-producers during 1894.

In general it may be said that the examinations of the Alabama Geological Survey during the past three years have shown that there is an abundance of low-grade gold ores in the State, which, at a number of localities in Chilton, Coosa, Tallapoosa, Talladega, Clay, Cleburne and Randolph Counties could be profitably worked by improved methods of concentration and extraction.

Graphite.—In Clay County, Alabama, and Bartow County, Georgia, plants were erected some time since for the preparation of graphite for lubricating purposes. During 1893 limited quantities were shipped from both places, but during 1894 the works have been idle, owing, it is claimed, to the limited demand, high rates of freight, and depressed condition of trade generally.

Iron Ores.—The iron ores worked in Georgia and Alabama are the brown hematite or limonite, and the red hematite, which are treated below separately.

Brown Hematite (*Limonite*).—In a portion of the State of Georgia, especially the counties of Polk and Bartow, as well as in the county of Cherokee in Alabama, the industry of mining brown iron ore has been for several years past the most important work carried on. In the counties of Talladega, Calhoun, Shelby, Blount, Etowah, Lauderdale, Franklin, Tuscaloosa, Bibb and Jefferson, in Alabama, this industry is also carried on, but not as extensively as in those first mentioned. One reason for this is that the product of the last-named counties is used locally, either as a mixture with the red fossiliferous ores in the Birmingham coke furnaces, or for treatment in the local charcoal furnaces; while the product from the first-named section is shipped to the large coke furnaces of Tennessee, as wellas into the Birmingham district, and to the Anniston coke furnaces. The demand for brown ore has been quite limited during 1894, because of the depressed state of the iron trade, consequently the production has been less than in 1892. Another reason for a reduced production has been the lack of water for washing at all of the largest washer plants, because of the extremely dry summer of 1894 in both Georgia and Alabama. A very marked and important feature in the brown ore regions is the decreased value of the ore, following the decline in pig-iron. Ore that sold in 1892 for $1.20 to $1.50 per ton f. o. b. at shipping point, declined in 1894 an average of 50c. per ton; consequently wages have declined in proportion from $1 per day, or 10c. an hour, in 1892, to 75c. and 80c. per day, or 7½c. and 8c. an hour, in 1894. The principal producers in Alabama in 1894 have been the mines of the Tecumseh Iron Company in Cherokee County. In Georgia the largest producers are the mines of the Augusta Mining and Investment Com-

pany, the North Georgia Mining Company, the Etna Furnace Company of Polk County, and the Central Mining Company of Bartow County.

The modern ore-washer plants which have been erected by these companies represent an investment of from $2500 to $10,000 at each plant, aside from the cost of water lines and pumping machinery. The washers near Cedartown in Polk County obtain their water supply from Cedar Creek, requiring a pipe line of from two to three miles in length, according to location of the washer. The Tecumseh Iron Company brings the bulk of its water supply from springs in Signal Mountain, a distance of about three miles. At Oredell in Polk County a pipe line three miles in length has recently been laid to furnish water for new washers in course of construction. This plant when complete will cost $20,000.

The lower part of the Silurian and upper part of the Cambrian formations yield the great bulk of the brown ores of Alabama, which are found in irregular deposits in several counties. Brown ores are also in places found in association with other formations, notably in Franklin and Lauderdale Counties, though the horizon named yields a very great proportion of the brown ore output of the State.

The total production of brown hematite in Georgia for 1894 was 101,196 long tons; in Alabama, from Cherokee County, the total production was 54,000 tons. From other portions of Alabama the total production cannot be ascertained exactly; but from reports returned by the majority of the producers, which show an aggregate output of 77,122 tons, there was a total output of not less than 100,000. This would give a grand total for the State of Alabama during 1894 of 154,000 long tons.

The following table will show the production in Georgia by months:

Month.	Long Tons.	Month.	Long Tons.	Month.	Long Tons.	Month.	Long Tons.
January	6,459	April	11,493	July	9,959	October	5,718
February	7,596	May	11,895	August	6,538	November	7,011
March	9,942	June	6,706	September	8,377	December	9,052

During 1894 the charcoal furnace at Rome, Ga., has been the only furnace in blast in that State. In Alabama, only seven coke furnaces in the Birmingham district have been in blast without interruption during the entire year, while none of the charcoal furnaces in the State have been in blast during that period without interruption or being blown out for several months at a time. At Shelby, Ironaton, and Round Mountain, in Alabama, the charcoal furnaces have been in blast a portion of the year only. The Bass furnace at Rock Run, Ala., has been rebuilt, and will be blown in early in 1895. The Anniston, Gadsden, and Jenifer furnaces, also in Alabama, have been out of blast the entire year, while in north Alabama but one furnace, that at Florence, has been in blast. The brown ores of Georgia and Alabama vary from 40% to 57% in metallic iron, and from 0.2% to 1.5% in phosphorus.

Red Hematite (Fossiliferous Ore).—Next in importance to the coal mining industry in the State of Alabama, the most prominent mineral industry is the mining of red hematite, from which the coke furnaces in the Birmingham district derive their supply of ore, except the small proportion of brown ore used in

mixing the charges. The seams of this ore vary from a few inches up to 33 ft. in thickness. The production of the mines of the Tennessee Coal, Iron and Railroad Company for 1894 was 700,427 tons; the production of other mines in the Birmingham district was 341,548 tons; making a total production of red hematite ore in Alabama for the year of 1,041,965 long tons.

Geologically, according to State Geologist Eugene A. Smith, the most important of the iron-bearing formations of Alabama is the Clinton or Red Mountain of the Upper Silurian. The ore is a fossiliferous, lenticular, and oölitic red hematite (an altered limestone), forming a constituent part of the Red Mountain ridges which border the various anticlinal valleys of the State on both sides, but with varying thickness and quality of ore. In the vicinity of Birmingham this ore bed thickens into 30 ft. and more, though not all of it is at present used, being rather high in silica. Experiments in concentrating this ore by means of magnetic separators will, it is hoped, result in the elaboration of a method by which the whole of it can be profitably used, even at the present low prices.

Limestone and Marble.—The limestone and marble of the Paleozoic formations in both Alabama and Georgia hold quite an important position commercially. Limestone is most important in Alabama, while marble has during the year 1894 occupied probably the first position among the mineral industries of Georgia. The general depression in the iron trade, with the reduced number of furnaces in blast, has been very severely felt in the limestone quarries in Jefferson, Cherokee, and Calhoun Counties, in Alabama, where the product is used chiefly for fluxing. Consequently the output has been very much reduced during the year, as compared with the output of the preceding ten years, especially from 1888 to 1891. The quantity mined for fluxing purposes in the Birmingham district during 1894 is reported as 213,505 long tons. The bulk of the limestone for lime burning is quarried in Bibb, Shelby, and Calhoun Counties, in Alabama. The largest and most important plant is located at Anniston, in Calhoun County; its capacity is 350 barrels of lime per day. The limestone and marble of Alabama are used locally for building purposes. The locks of the Muscle Shoals Canal, in north Alabama, were constructed of limestone quarried along the Tennessee River, in Colbert, Lauderdale, and Limestone Counties. In Georgia the marble industry has assumed large proportions, especially in Pickens County in the vicinity of Tate. A bulletin has recently been published by the State Geological Survey relating to the beds of marble, their economic importance, and value.

According to the Alabama Geological Survey, most of the limestone used for flux in the iron furnaces comes from the Mountain limestone horizon of the Subcarboniferous, but at several localities the Trenton limestone is also brought under contribution, and in a few instances the dolomite of the lower Silurian, or Knox Dolomite, is finding favor on account of the uniformly very low percentage of silica. For the production of lime, the Trenton is extensively used, and in one locality a crystalline dolomite in the lower part of the region of the crystalline schists has been continually quarried for lime-burning for more than 50 years.

Manganese Ores.—The shipments of these ores, as reported by Satterfield & Sons of Cartersville, Ga., who have been the only shippers during 1894, report that

shipments have increased from 500 tons in 1893 to about 1920 tons in 1894, or an average of 160 tons per month. These shipments have been made to the Carnegie Steel Works, and to chemical works in New York, Boston, Philadelphia, and Pittsburg. The ores are sold on the unit basis, and payment is made on the analysis at the works to which consignments are made. During the past year the price has averaged 30c. per unit f. o. b. at point of consignment. The freight rates vary from about $5 per ton upward, according to location of market. The ore shipped, I am informed, varies in percentage of manganese from 40% to 45%, occasionally running higher. The proportion of phosphorus averages less than 1%. Previous to 1893 the production of manganese in Georgia was divided between Floyd and Bartow Counties, but the mines near Cave Spring, in Floyd County, were closed down in the spring of 1893, and since then Bartow County has been the only producer. Mining and washing are carried on to a limited extent only, in the vicinity of Cartersville, by lessees who pay royalty to the landowners, and sell to the local shippers for about $4 a ton f. o. b. cars. The Etowah Company, near Cartersville, which erected a large washer, and constructed a branch railroad about 4 miles in length, a few years since, has not actively operated any mines during 1894, the reason assigned being that the high freight rates, added to cost of mining and washing, render the industry unprofitable.

Mica.—The mica mining industry during the past year has been very much depressed. Only one mine in Alabama produced any for market, and that only a limited quantity. This is located in Randolph County, at Pinetuckey. Quite recently a new company commenced operations, and is putting in hoisting and pumping machinery, preparatory to more extensive development. Some prospecting was done in the vicinity early in the year, but the general depression caused a cessation of work. The quality of the Alabama mica has been pronounced by experts of the General Electric Company satisfactory for electrical purposes. The question now is whether crystals of sufficient size to command a price high enough to make mining profitable can be found. The mica mines of Georgia were non-producers in 1894.

Ocher.—Floyd and Bartow Counties in Georgia contain several beds of ocher, some of which have been developed more or less extensively, and shipments made to the Eastern markets. During 1894 about 360 tons were shipped from Cartersville, in Bartow County, and a limited quantity from Emerson, in the same county. A plant for the preparation of the crude ocher was erected in Bartow County some years since, but has not been actively operated during the past year. The deposits in Floyd County have been prospected to some extent, but cannot yet be classed as producers on a commercial scale.

Pyrites.—During the past year considerable activity has been manifested by the prospectors in searching for this mineral in order to supply the acid plants at Atlanta and Montgomery. This work has been carried on principally in Lumpkin and Paulding Counties in Georgia, and Clay County, Alabama. In the first named an old copper mine was reopened, and a body of solid pyrites exposed, from which 200 tons were shipped to Atlanta, and tested by the Scott Manufacturing Company. The result was not made public, but the superintendent at the mine was instructed to continue shipments. The location of this

mine, 20 mines from the nearest line of railroad, will prove a serious drawback. In Paulding County an old mine has been reopened in which pyrites occur disseminated through the green semi-crystalline slate country rock in small crystals or cubes. The pyrite forms about 75% of the mass of slate, and an analysis of carload samples shipped to Charleston, S. C., showed about 47% sulphur. The present construction of the furnaces of the acid plants in Atlanta prevents the use of any but solid massive pyrites; consequently this product cannot be utilized at present except at a small number of furnaces on the coast. The same variety of pyrite is being prospected in Clay County, Alabama, but remoteness from railroad facilities, as well as lack of demand at present, prevent shipments. This form of pyrite is quite extensive, both in Georgia and Alabama, occurring in a semi-crystalline slate, designated as "Iwana" by Dr. Eugene A. Smith, State Geologist of Alabama, to distinguish it from the "Talladega" (Ocoee, Algonkian) slate, which is the prevailing country rock of a large proportion of the gold occurrences in both States. If the acid manufacturers can be convinced of the extent of this ore, and if analysis shows that it carries a sufficiently high percentage of sulphur, there is no doubt that it will in time displace the Spanish ore.

Soapstone.—The extensive quarries of steatite or soapstone, which occur in three distinct belts or leads in Alabama, and maintain continuity through Georgia, are remote from railroad facilities, and consequently are only utilized locally for chimneys and blacksmith forges. This material was used in the construction of the copper smelters put up in Cleburne County, Alabama, in the '70s.

Tantalite.—About $600 worth of crystals of this rare mineral have been purchased from residents in the vicinity of Rockford, the county seat of Coosa County, Alabama, during the year. Specimens are found from time to time, and preserved by the residents, or sold for cabinet collections.

ALASKA.

The gold mining industry of Alaska remained in the year 1894 the chief and indeed the only important one of that Territory, as in previous years. The most important event of the year was the success of the Alaska-Mexican Mining Company, a new concern, which was organized in 1893 to work the old Bear's Nest mine—of somewhat unsavory memory—near the Alaska-Treadwell on Douglas Island. The new company proved more successful than the original purchasers of the property, and opened up a deposit of low-grade ore, said to be of considerable extent, similar in nature to the Treadwell ores. In its first year of operation 36,541 tons were worked at an average cost of $2.06 per ton, the average return being $2.77, and leaving a profit of $0.71 per ton. In November this company became a dividend payer, returning to its stockholders a payment of $30,000, or 15c. per share.

The Alaska-Treadwell has continued its usual course, but during 1894 its output was somewhat reduced by the lower grade of the ores taken from the mine. For the year ending with May, 1894, the company's mill worked 220,043 tons of ore, the average yield being $3.20 per ton and the cost $1.35; while for the six months from May to November the average yield—on 122,282 tons—fell to $2.51 per ton, the cost being $1.38. In spite of this reduction in net proceeds from $1.85 to $1.13 per ton, the company has been able to maintain its dividends

without interruption. It is only fair to say that the reduction in value is attributed to the fact that extensive development work prevented the taking of ore from the lower levels to a large extent, so that most of that worked was from the upper and poorer part of the ore body.

Aside from these two companies the returns from the Territory have not been large. At several points exploration and development work have been carried on, but without any immediate results in output. At Sheep Creek and Unger some work has been carried on, and at Silver Bow Basin a large group of claims was sold to California mining men, who have made preparations for extensive work in 1895. At Berners Bay work has been done on several claims and arrangements made for handling the ore, but no definite results are reported.

In the Sumdum mines nothing new can be noted, with the exception of some transfers of property, the principal one being the sale of the Bald Eagle group of claims to California parties.

The effect of the general tendency toward gold mining was felt in Alaska, and in the spring an unusually large number of prospectors started for the placers on the Yukon, the value of which has been very variously estimated in the past. The work of the present season has not served to increase our knowledge much, since the accounts of results so far received have been very contradictory, and nothing definite can be given as to the returns of the season. A few of the prospectors, however, remained, having obtained enough to induce them to spend the winter in that far northern region.

Upon the whole the work of the year in Alaska has been of promise and preparation rather than of performance, and while the Territory has held its own as a gold producer no material increase can be reported.

Arizona.

The marked feature of the year in Arizona has been the extraordinary increase in the yield of the gold mines of the territory, proceeding as in most of the other mining States, both from new discoveries and explorations, and from increased activity in working older properties. According to information collected by Mr. John F. Blandy, the production of gold from Arizona mines in 1894 was 96,313 oz. against 58,911 oz. in 1893, showing an increase of no less than 37,402 oz. or 63%. On the other hand the silver production showed the effect of the low price of the metal and the general depression, having fallen from 2,935,700 fine oz. in 1893 to 1,539,453 fine oz. in 1894, a decrease of 1,396,247 oz. or 46%.

While the activity in gold mining, Mr. Blandy writes, was felt in a greater or less degree all over the territory, the mines of Yavapai County took the lead, the production of that county showing an increase of 155%, rising from 16,987 oz. of gold in 1893 to 43,392 oz. in 1894. The figures for the latter year have been very closely collected, but are more likely to be a little below the truth than above it, since, as all who are familiar with the country know, small bars are often carried away by private conveyance and escape enumeration in the totals. In this county the activity in gold mining and production still continues in a great degree, and there is every reason to expect a continued growth in the output. The gain is a large one and is beginning to attract the capital for the want

of which Arizona mines have suffered so much in the past. Notwithstanding the quantity of gold produced, there are in the county now only four mines which have been systematically developed and are fully equiped with hoisting machinery and plants for working the ore, and at three of these the mill capacity is still below that of the mines. It is also worthy of note, that these four mines, which together produced more than half the total output of the county, were all brought to their present condition and equipment without any outside help, improvements having been made from time to time from the product of the mines. It may perhaps be interesting, and will certainly give an indication of the past course of mining in Arizona, to give the brief history of each of these properties.

One was patiently worked by arrastras for ten or twelve years before it was taken hold of by more enterprising owners, and the newcomers soon sunk a shaft and put up a fine stamp mill, mostly on credit, and in the first year produced more than had been taken out in the previous ten.

A second one of this group was given away by the discoverers as of but little account. The next transfer was that the owner gave it and a burro in payment of a $200 debt. The new owner after trying it considered that he had been badly cheated and demanded his $200, which he took in the form of a note. A more determined prospector finding rich float there took a lease on it and soon proved it to be a valuable ledge. It is now yielding $300 to $400 per day in free gold, besides rich concentrates.

The third mine of the group was discovered in 1871, and was considered valuable, but the Indian troubles, and still more the great expenses of getting to and from the locality, caused it to lay idle for a number of years. It is only within the last five years that it has been successfully worked, and is proving itself to be all that was at first claimed for it.

The fourth was held for several years by prospectors with small returns. It was finally purchased by a capitalist, who after paying for it said, "now make it pay" and refused to put any more money into the enterprise. It did pay under more energetic hands and has become the largest producer in the Territory.

There are in Yavapai County over 100 gold-bearing veins which are known and have been explored to a greater or less extent, and over 200 claims have been located on these veins. The progress, however, is necessarily slow unless some outside capital can be secured. In nearly every case development work is needed to put the claims on a producing basis, and most of the present holders are unable to do more than the necessary assessment work to hold the claims, although the laws of the Territory are very lax on this point. A good mining law like that of Colorado in relation to locating and holding claims would work a great change throughout the Territory. Under the present system men are able to hold too much ground from year to year by re-locating, and thus prevent the transfer of the claims to those who are able to work them on a proper basis. An attempt has been made to secure such a law from the legislature, but with very little prospect of success during the present year.*

A great majority of the gold-bearing veins in Arizona have been found in the

* Since writing this the legislature has passed a law similar to the Colorado statute..

granite and porphyries and the remainder in the crystalline schists; they can therefore be considered as true veins, and probably permanent in their yield. Without exception up to the present time the ores become base at a short distance below the surface, but the free gold shows an increase in depth. In one notable instance the quantity of free gold increased from an average of $10 per ton near the surface to $20 at the depth of 300 ft., the remainder of the ore being very base. The most common admixtures found in Arizona ores are zincblende and copper pyrites, both occasionally occurring in the same vein. Very little arsenical pyrites are found. In a few instances segregated quartz veins have been worked in the granite, but with very little success as they are too lowgrade to yield a profit. Some veins in the crystalline schists follow the strata in their courses and dips, but these veins are usually uncertain and pockety in their nature, and though rich in places have not been reliable enough to be profitable upon the whole.

In general it may be said that the future of gold mining in Arizona is promising, though the results for some years to come depend largely upon the extent to which investors of capital can be secured. Of silver mining but little can be said, as its future depends entirely upon the general conditions which have affected the industry all over the world.

The copper mines of Arizona, while maintaining a fair degree of activity, have not increased their output, and have done but little new work. The low price of copper and the large supply furnished by the Montana and Lake Superior producers have not encouraged the Arizona miners to add to the amount of metal forced upon the market. The exception to this has been the undertaking of some new operations at Jerome, under the control of Mr. W. A. Clark. The extent of the work there and the amount of development have been kept strictly secret, and no reliable statement can be obtained regarding them. It is known, however, that Mr. Clark is building a narrow-gauge railroad from the mines to a connection with the Sante Fe, Phœnix & Prescott Railroad, and that a large Bessemer plant is being erected there for the purpose of turning out matte. It is said that when it is in operation the production will amount to 1,500,000 lbs. monthly. Other particulars relating to the copper mines will be found in the article on that metal.

No work has been done on the very promising deposits of lithographic stone which were described by Mr. John F. Blandy in the *Engineering and Mining Journal*. Some stone has been taken out for experimental purposes, but the deposits have not been worked in a commercial way.

The Mining Industry in California.

By W. H. Storms.

Within the past two years the mining situation and outlook in the State of California has improved wonderfully. There are 23 counties in the State where mining is an important industry, and in several of them it is almost the only one, while there are 18 others in which mining and quarrying give employment to a large number of men. New life has been infused into the industry everywhere and the tendency on the part of capital is toward investigation. New investments and enterprises, some of considerable magnitude, are now heard of almost daily. Not only are resident capitalists making investments, but from many of the larger cities of the United States, and also from Europe, they are attracted toward California gold mines, for it is to this branch of the industry that attention is being particularly directed. In California this healthy condition of affairs has not been spontaneous; it has come gradually. For two years past the mining industry has shown an upward, progressive movement. New discoveries have been numerous, notwithstanding the fact that it is the oldest mining State west of the Mississippi. Not a few mines, long since abandoned, have been reopened, and it is an encouraging and significant fact, that thus far the renewal of operations in these old mines has been generally attended with success. It has been, and is to-day, being demonstrated in the most substantial and practical manner, that the great fissures of the gold belt "go down," and that they carry shoots of ore which will make returns to those who are bold enough to go after them. The greatest depth attained in any of these mother lode mines shows no deterioration in the value of the quartz, as compared with the upper portions of the vein, the ore being just as rich as any found near the surface. There are a number of shafts in the gold mines of this State considerably over 2000 ft. deep, a score of them deeper than 1500 ft., and a great many more than a 1000 ft., and some of the deepest are going still deeper.

Among the mines where long-suspended operations have been followed by resumption (mostly under new ownership and management) may be mentioned the Pioneer, the New London, the Mahoney, and the Hardenburg in Amador County; the Gwin, the Boston, and the Calaveras Consolidated in Calaveras County; the several mines of the Cook estate in Mariposa County, and a dozen or more mines in Tuolumne County, the most prominent of which is the Mammoth. Beside these there are many smaller enterprises with fair chances of success and some of them most promising. Each of the larger operations above referred to appears already to have success assured. These successes will have a very beneficial effect on the industry as a whole, and if "wild cats" do not become too numerous, the resumption of operations in long-abandoned mines is likely to continue for some time to come. In most cases a large outlay is required, as these old mines are often deep, flooded, frequently caved and inaccessible. Old shafts must be retimbered, the mines unwatered, and in many places new hoisting, pumping and milling machinery is required.

Among the new enterprises where capital has been interested in opening and equipping promising prospects there are several large concerns. In San Diego County the Golden Cross Mining Company has acquired a group of mines for-

merly known as the Gold Rock property; a 40-stamp mill has been built, and a pipe line laid 14 miles to the Colorado River, from which 120,000 gals. of water are pumped daily, being raised to a height of nearly 500 ft., at a cost of about $20 a day. The capacity of the mill is 100 tons, so that water costs here, on the desert, about 20c. per ton of ore worked.

The Julian district, in this county, has not enjoyed a prosperity anything like that now prevailing there within the past 15 years. Twenty or more mines are in active operation, most of them under a system of leases, the quartz being crushed in custom mills. The old Cargo Muchacho mine has been operated steadily for the past two years or more after a long idleness, and several mining enterprises of smaller caliber on the desert are being investigated.

In Riverside County there are several successful enterprises organized within the past two years. These are the Good Hope and the Santa Rosa, near Perris, and on the desert the Lost Horse and the Piñon Mountain.

In the San Bernardino Mountains the Rose mine and the Morango King Company's mines are operating, and the Altura Company are developing a promising prospect. There is also talk of resuming operations on the once famous Gold Mountain (Lucky Baldwin's) mine, near Bear Valley. After repeated failures the Holcomb Valley Company, Limited, of London, is successfully working its placer ground in Holcomb Valley, employing a huge dredging machine in the operation. In the eastern part of San Bernardino County the Vanderbilt district has developed some veins of rich ore, and at least two of the companies operating there are on a paying basis. Several new camps have been established in that section, the most noted being Shadow Mountain and Goldstone. Gold has also recently been found northeast and northwest of Calico, where the mines have been exclusively of silver.

The silver mining industry in this State is still centered in the Calico district. The legal complications which have existed there for several years past are now compromised, it is understood, and the mines are to be started up once more on a larger scale than has obtained at any time since 1891. The ores are almost exclusively chloride, very free milling, and the conditions are now such that a very low grade of ore pays a profit.

In Los Angeles County the Red Rover mine, near Acton, is again in operation after a long suspension, and several mines on Mount Gleason have been investigated by capitalists within the past few months.

In Kern County several new mining districts have been discovered, the most noted of which are the Red Rock and the Goler, and some mines near Panamint.

In Inyo, Alpine and Mono Counties, on the east slope of the Sierras, there has been a decided increase in interest, and many old mines are being worked again after years of idleness. At the Standard mine at Bodie the installation of an electric plant, transmitting power a distance of more than 12 miles, has effected a marked saving in operating expense. The success achieved in this instance has opened a new line of possibilities, and there is no doubt that electricity from this time forward is to play a prominent part in the economy of mining in this State, particularly where fuel is costly or not obtainable at all near the mine. There are many cases where an electric plant may be established

on a line of railway, where coal is obtainable, and the power transmitted 10 or 20 miles, or even further, to mines situated at that distance from the road, thus overcoming expensive transportation. In the middle mining counties and northward where many water powers are found, electricity will be employed to transmit power to mines and mills situated 1000 ft. or more above the generators. This has already been done at the Mammoth mine at Grub Gulch, in Madera County, the generator being 500 ft. below on the Fresno River. A similar application, it is understood, will be made at the mines of the Cook estate in Mariposa County, where the mines lie 1000 to 1200 ft. higher than the cañon of the Merced. These mines have recently been purchased by Eastern capitalists. The Whitlock mine, a valuable prospect near Mariposa, has lately passed into the hands of the well known Sierra Buttes Company, which has also acquired the Mammoth mine, near Jacksonville, in Tuolumne County. Both of these properties are being thoroughly developed and equipped with the latest improved machinery.

The output of the Utica-Stickles group at Angel's Camp, Calaveras County, has given an impetus to mining generally in that section. Several mines, large and small, are being opened near San Andreas and Mokelumne Hill, both quartz and drift mines as well as hydraulic. Beside the mines already mentioned in Amador County, the Argonaut, adjoining the Kennedy on the south, is sinking a shaft which is intended to attain a depth of 2000 ft., and it is expected to penetrate the hanging wall to a depth of 1000 ft., or thereabouts, before the fissure is encountered. Nearly a mile southerly the Alma shaft is being sunk, and this shaft will also be a deep one. Between Jackson and Sutter Creek the South Eureka shaft has been sunk over 1000 ft., and recently a fine body of quartz has been uncovered.

In El Dorado County there are several new enterprises, the foremost of which is the Oro Fino. It was at this mine that A. Hayward, the owner, introduced 1400-lb. stamps. The innovation is not looked upon with much favor, however.

In Nevada, Butte and Plumas Counties there are a number of new mines, while in Siskiyou there are 400 operating mines—quartz, placer, hydraulic and drift. At least 40% of these have come into notice within the past two years.

Shasta County has several new and large operations. The Iron Mountain is the largest. This property changed hands not long since and will be operated on a more extensive scale than at any time in the past.

Trinity County is one of the foremost of the mining counties, and is not behind other sections in new operations and renewals of older ones.

In fact, the entire State shows a phenomenal increase of operating mines, and the output of the past few years, which has been about $13,000,000, is likely to be increased by several millions in 1895, and doubtless to a greater extent in 1896.

Hydraulic mining, so long inhibited, has been resumed in several counties under the restrictions of the debris act. Upward of 100 applications have been filed with the Debris Commission for permission to mine, of which about half have been granted. Several were refused and quite a number are still under consideration. Of the permits granted, most of the mines have commenced operations or are taking active steps in the work of preparation. This renewal of hydraulic operations will swell the gold production of the State very materially.

Colorado.

By T. A. Rickard.

The year 1893 in the annals of the mining industry of the West was marked by a period of apparent paralysis. The collapse in silver disorganized all business enterprise. The year 1894, however, has seen the rapid recovery which follows convalescence. It its passage through the school of adversity the mining industry of Colorado has learned lessons of far-reaching importance. The miner—and the smelter too—has been compelled to practice that economy which is so foreign to his character. System and business caution have crept into every avenue of the multifarious ways of mining and metallurgy.

If we turn first to the actual extraction of the ore at the mine, we find that as a natural consequence of the drop in silver there has come a necessity for a close attention to details which were previously overlooked. While gold mining was not directly affected by the hard times there can nevertheless be no doubt but that the spirit of economy engendered in silver mining has proved infectious to those engaged in the extraction of the other metal. In the work of breaking the ore better methods have been introduced for keeping it unmixed with waste rock. Ore sorters have, in many instances, been diminished in number, in other cases entirely dispensed with, as a consequence of cleaner work underground. In the opening up of the mines a closer attention to the geological structure of the country has followed from the necessity of avoiding the driving of unnecessary levels and cross-cuts. Haphazard, if not blind, prospecting and reckless development have become less common, because such methods of searching for ore are too costly for the present dispensation.

More important, however, than these has been the introduction into some parts of the State, and the extension in others, of the contract system. The decline in wages has antagonized the labor unions. The spread of the railroad has lowered the standard of skill required of the miners by the incoming of inexperienced workmen from the farming regions. By working on contract a mine manager follows the scientific teaching of the times—the survival of those that are fittest. Idle men cannot make wages, incompetent ones must go to the wall or else set about to become competent with as little delay as possible. Wherever introduced, whether in drifting, cross-cutting, stoping or tramming, the contract system has diminished the costs of operation. Its successful application demands experience, but its superiority over all other methods is based on one fact which no conditions can alter—that a man works better for himself than he will for others.

In the mountain regions of Colorado, where mines are situated at altitudes of 8000 and 10,000 ft. above sea level, the cost of transport is a depressing item of expenditure. The rapid extension of the use of aërial ropeways and the adoption of Bleichert, Huson and Hallidie tramways has done much to minimize this expense. The southwestern and most rugged part of the State has offered a fine field for engineering ingenuity in the adaptation of standard methods to local conditions.

Better, perhaps, than the cheapening of transport is the lessening of the proportion of the ore requiring transportation by the use of successful concentration. The operation of mills above timber line—10,500 to 11,500 ft.—was not

many years ago considered a vain imagining. It is a substantial fact now. The conversion of the energy of the mountain torrent into electricity, and its subsequent transmission for long distances, render concentration in comparatively inaccessible localities entirely feasible. The recent development of the multiphase system renders practicable the operation by electricity of all classes of machinery in a manner impossible with the direct current. Being an alternating system it is possible to use high voltages, and by means of step-up and step-down transformers the current can be converted into any electromotive force required. The direct current being limited in practice to, say, 700 volts, and the single phase alternating current being impracticable for varying loads, the multiphase system, having no such restrictions, comes as a great boon to the mining engineer. Again, the employment of a high voltage enables the engineer to get sufficient horse-power (watts) with a small amount (ampères) of current and, since the latter is directly proportioned to the size of the copper wire required for its transmission, this recent development therefore permits of long distance transmission without an excessive investment of capital. The electric transmission plant of the Silver Lake mines in the San Juan region is an excellent illustration of the most advanced development of combined electrical and mining engineering.

In the actual pattern of the concentrating mills themselves there is no noteworthy change. The plant of the Smuggler Mining Company at Aspen is designed on the lines of German practice, and is probably the most complete establishment of its kind in Colorado. The reproduction of European methods, while it may tend to technical perfection is, however, rarely desirable, because local conditions do not often render it profitable to turn out a variety of products such as would find a ready sale in the old world.

While the copying outright of mills of German design is not to be commended, there is no doubt that the best thing the Western millman can do just now is to pay more attention to that one factor in successful concentration which the Germans have done so much to perfect. I refer to proper sizing before jigging. Indifference on this score has been a serious stumbling-block to the attainment of good results in mills which were otherwise excellently designed.

Bad blunders have often been made in the West by the failure to re-crush the tailings from jigs or other similar machines. The choice of a pulverizer suited for such work has long been a perplexing problem to the millman. The experience of several Colorado mills has pointed of late to the newest form of the Huntingdon mill as a machine eminently adapted for such a purpose.

In the matter of stamp milling, the past year has seen an earnest effort to introduce the Californian method of fast drop and low issue in place of the old Colorado practice of slow drop and deep discharge. Compromise mills have also been erected. While the Colorado method is doubtless out of date, it is improbable that in its own particular habitat—Gilpin County—it will be replaced by that of the Pacific coast. Local conditions of a peculiar kind militate against the change. Elsewhere in the State, however, the innovation is making headway, and is calculated to prove beneficial. One result is unquestioned, namely, that it has directed attention to the employment of those labor-saving appliances which

have made the Californian stamp mill the cheapest ore-reducing mechanism yet invented by the ingenuity of man.

Water concentration is frequently impossible where nature has already concentrated her ores. Material rich in sulphides can, however, be diminished in bulk and correspondingly increased in value by fire concentration such as takes place in matte smelting. Pyritic smelting, as described in scientific literature, is still much of an iridescent dream. The utilization as fuel of the iron and sulphur of the pyrite does not take place to the extent prophesied by metallurgical hierophants. Pyritic smelting has nevertheless been of inestimable service to Colorado in demonstrating that desulphurization can take place under certain conditions in an ordinary lead blast furnace to an extent formerly not realized.

Several establishments have been working the pyritic process. Of these the Bimetallic Smelter at Leadville is the most important. Three furnaces have been treating the sulphide ores of the Henriette and Maid of Erin mines at Leadville and the silicious ores of the Amethyst mine at Creede. During the year the tonnage treated by this plant amounted to 60,000 tons. The concentration, effected in two operations, has been finally in the ratio of about 15 into 1. The amount of coke used is said to have been about 12% to 15%. The hot blast, one of the stated prime requisites of the Austin process, has been discarded without seeming detriment. The men who are at the back of this enterprise are large mine owners, and they therefore control a varied ore supply; they also command a large amount of capital and are able to carry heavy stocks of matte at such times as the market is not ready to absorb them. The conditions which have obtained would have long ago broken the back of a more feeble concern.

In the San Juan region matte smelting has been a very important factor. At Silverton a new plant has been erected designed to use the Austin patents of the pyritic process. At Rico an old plant has been transformed into a matting furnace. These two local establishments have helped by their competition to reduce the treatment charges levied by the smelters at Durango, the central smelting point of the Western slope. At Silverton the command of ores rich in copper and iron pyrites is assured by the mines of Red Mountain, but the corresponding supply of silicious ore has been hard to obtain. The dearth of such material has handicapped the smelter, but it has served to energize many hitherto idle mines.

The hot blast is used successfully at Silverton. Its utility is made evident in the additional capacity* of the furnace and in the diminished consumption of fuel.† Two concentrations are required to put an average of 13 tons into 1.‡ The amount of coke consumed has been decreased until now it approximates 5% only. The coal used for heating the blast averages 4½%.

In this case, as at the Bimetallic Smelter, the addition of a goodly percentage of coke prevents the attainment of the ideal conditions required for the proper burning of the iron and sulphur according to the true theory of pyritic smelting. It has, indeed, been proved that the furnace can be run for short intervals under

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* Increased from 85 to 105 tons.

† Five tons of coke in the furnace and 4½ tons of coal in the stove have replaced the 15 tons of coke required in the furnace when cold blast was used.

‡ The initial charge contains 3% to 4% copper and the final matte 45% to 52%.

certain conditions without the addition of ordinary fuel, but in everyday practice the maintenance of such conditions has not proved practicable, and the consumption of fuel* has approximated that of the ordinary lead blast furnace process.

The work done at Kokomo, at Leadville, and at Silverton does, however, indicate that as a method of fire concentration for low-grade ores in localities devoid of material suitable for ordinary lead smelting the pyritic process will be of great service to the mining industry.

Nothing epoch-making has occurred in ordinary lead smelting. Former methods remain practically unchanged, with a constant tendency toward an increase of capacity in the furnaces, accompanied by a cheaper handling of all the materials. Enlargement of the furnaces has reached a maximum area at the tuyères of 140 by 42 in., with a distance to the exit flue of about 16 ft. Large overflow slag-pots, permitting of the settling of intermingled matte, have found extended introduction. In this connection it is noteworthy that the making of matte, formerly only an incident in lead smelting, has now become an important part of the process.

In copper smelting the gradual enlargement of the reverberatory requires mention. The last furnace erected at Argo† has an average daily capacity of over 50 tons, with a maximum of 60 tons.‡ Half the charge consists of roasted ore fed hot, the remainder being cold silicious material which has not been roasted. If the entire charge were hot roasted ore the capacity of the furnace would necessarily be considerably augmented. This latest extension of the reverberatory enables it to approximate the capacity of the average lead blast furnace, and is an event of much interest. Further enlargement is probable. The Pearce turret mechanical roaster, first designed at Argo, has extended its field of usefulness during the year, and has proved helpful to many establishments in this State and outside of it. It is particularly adapted for the preparation of ores destined to undergo the reactions of reverberatory smelting, and it is fast supplanting the older forms of roasting furnaces in the preparation of material previous to chlorination.

The smelting works of Colorado have a capacity of between 3500 and 4000 tons per day. At the present time the actual tonnage treated daily does not exceed 1500. This is mainly due to the diminution in the output of ore following the closing down of many silver mines and the restriction of operations in others. While the tonnage has dwindled, the average tenor of the ore has increased, since it is usually the low-grade silver mine which has been compelled to shut down. Richer ores have made richer bullion, and greater care and skill in smelting operations have therefore become imperative. The tendency is to replace costly iron fluxes by earthy bases with the formation of a slag of such liquidity as will facilitate a ready separation of the matte.

The creation of a clearing-house at Denver has permitted the distribution of the ore supply without cutthroat competition, and has enabled the smelters to

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* As coke in the furnace itself and as coal in the stove used for heating the blast.

† By the Boston & Colorado Smelting Company.

‡ Its dimensions are 35 by 16 ft. The development of these furnaces is fully treated under the head of "Copper" in this volume.

run without the accumulation of the large stocks of ore previously considered necessary to their successful operation. Treatment charges have not been seriously affected; those levied upon lead and iron ores have gone up because there has been a comparative excess of such material, but, on the other hand, the charges on silicious ores have materially declined.

The field for wet processes of ore reduction is very much narrowed in Colorado because of the distribution at Durango, Leadville, Pueblo and Denver of a number of splendidly equipped smelting plants. The low-grade quartz ores of Cripple Creek have, however, incited the skill and enterprise of those who are versed in leaching methods. Much of the ore of that mining region is too poor to undergo shipment to a distant smelter, and too refractory for ordinary stamp milling. Hitherto in Colorado the stamp mill and the concentrator have sufficed to treat the ores unused by the smelter. A chlorination plant erected a few years ago in Denver was unable to survive the fierce competition to which it was subjected by the smelters. Silver leaching mills, in Colorado, have usually been only disfigurements of the scenery. The cyanide process, whose headquarters for America are in Denver, has enjoyed but a precarious existence until now, when it has locked horns with chlorination in competitive trial over the ores of Cripple Creek. The small plant at that place, which has been at work with very unequal results for more than a year, is being remodeled. At Florence a large, complete and well-designed establishment is being erected by the Metallic Extraction Company. This latter plant will, in its plan and mode of operation, follow the very latest developments in the practice of cyanidation. Its capacity is 150 tons per day. Dry crushing will precede agitation. The removal of the dust by pneumatic classifiers and the separate leaching of the fines and the coarse pulp is expected to diminish the mechanical difficulties incident to all leaching methods. Very few of the numerous improvements which have been suggested in the delicate chemistry of the cyanide process have as yet been endorsed by the test of practical application, and it would appear that it is in the bettering of the mechanical conditions surrounding leaching and filtering that there will be found the readiest road to improvement.

The claim often made in behalf of cyanidation as against chlorination, that the former does not and the latter does require a previous preparatory roasting of the ore, is being minimized by the fact that a rough calcination is in many cases advisable, even in cyanidation, because of the physical, rather than chemical, changes produced in the ore; changes rendering the material more friable, and so more easily pulverized, and more porous, and therefore better leached and more quickly filtered.

There are two chlorination plants at work in the Cripple Creek region, one having a capacity of 75 tons and the other of 50 tons per day. The experience of Dakota and the Carolinas has been utilized and the barrel process adopted. Both the leaching and filtering take place in the barrel itself, so that the use of supplementary filtering tanks is dispensed with. The experience of many tests has proved that the treatment of raw unroasted millstuff is not to be recommended, even where an analysis shows the ore to be devoid of sulphur. The extra cost of roasting is inconsiderable, and, as in the case of cyanidation, is directly favorable to rapid leaching and filtering. Experiments have indicated

that bromine may in the near future replace chlorine. Bromination is said to be less troublesome, more rapid, and therefore may prove less costly.*

The present year will undoubtedly see a close rivalry and a fair trial between the various leaching processes which are struggling for supremacy. In the meantime, every week has its announcement of the invention of some new process destined to revolutionize metallurgy and to regenerate mining. The history of the established methods of the day tells, however, a story of slow evolution and gradual improvement. It is improbable that any heaven-sent revelation will render all ores amenable to successful reduction or nullify all the experience of the past. It is in the path of an improved application of well-tried methods that the surest progress lies. Such is indicated by the necessarily brief glance which has been taken of the diversified field of mining and metallurgical activity. The evidence afforded proves that Colorado has met adversity with resourcefulness and hard times with harder energy. Few regions present so many interesting problems to technical science, and in none is there evidence of more ability to overcome the difficulties which present themselves from day to day to the mining engineer and the metallurgist.

WYOMING.

By WILBUR C. KNIGHT.

THE mineral resources of Wyoming are extensive and diversified, but the development so far has been so meager that no one can safely estimate the possibilities. This inactivity in the mineral industries is due to lack of transportation and want of suitable markets. There are three systems of railroad in the State, but, with the exception of the coal lands, they do not pass through the mineralized sections, and the Union Pacific is the only one that crosses a mountain range, so that the most valuable localities, from a mineral standpoint, are from 25 to 150 miles from railroad transportation. In cases where various minerals have been freighted to the railroad it has been impossible to secure such rates as to make the mineral industries profitable. The building stones, lime, plaster and mineral paint, for instance, cannot be shipped even to the Missouri River so that they can successfully compete with products of equal grades from other localities. Notwithstanding these drawbacks, there is year by year a gradual increase in mining operations and production.

The mineral output of the State for 1894 decreased in some lines, but the new industries more than made up for the loss, so that for 1894 Wyoming shows at least one step in advancement. Some notes on the different minerals are given below:

Asbestos.—The asbestos camp at the Seminoe Mountains and at Grand Encampment Creek in Carbon County, as well as at Laramie Park, Albany County, were inactive during the year. At Casper Mountain, in Natrona County, a large amount of development has been accomplished, but no shipments made.

Coal.—Coal mining is at present by far the most important mineral industry of the State. The total output for the year 1894 was as follows: Shipping

* Under conditions such as obtain in Colorado, with the use of the most modern methods of crushing and roasting, the total cost of chlorination approximates $3 per ton.

mines, 2,207,135 tons (of 2000 lbs.); local mines, 17,000 tons—total, 2,224,135 tons, valued at $2,864,891. This shows a small decrease—19,266 tons—from 1893, due chiefly to local causes, such as mine accidents. The coal industry of the State is fully treated in the article on "Coal," elsewhere in this volume.

Gold and Silver.—Mines were operated in Albany, Crook, Fremont and Uinta Counties, but it has been impossible to secure the output, since the placer miners are at their claims only during the spring and summer, and the quartz mines are operated by private owners, and returns are not available. The production, however, has been very small, when compared with that of some other mining States. Prospecting was very extensively carried on in the mountains during the season, and several new camps were reported which will be opened up during 1895, but were not producers in 1894.

Iron.—The iron camps at Hartville, the Seminoe Mountains and Rawlins all received considerable attention during the year. The mines at Rawlins commenced shipping a red hematite ore, averaging above 60% in metallic iron, last August, and by the end of December had produced 1400 tons of ore, valued at $5600.

Petroleum.—An account of the Wyoming fields will be found in the article under this title.

Plaster of Paris.—Owing to the general depression of business in the West, the demand for plaster has been so small that the plant at Red Buttes was in operation for only a portion of a month. The output was 250 tons, valued at $2500.

Sodium Sulphate.—The plant for calcining the natural product was in operation in 1894. The company has collected a large tonnage of crystals in preparation for an active year in 1895. A description of the deposits will be found below.

Other Minerals.—The copper and lead mines have been inactive during the year, and there has been but little development. The graphite mines at Halleck Cañon were worked to some extent, but none of the product was shipped. This graphite ore is associated with a clayey material and assays from 30% to 45% carbon. The other mineral prospects and mines, such as manganese, sulphur, tin, mica, bismuth, arsenic, etc., have been prospected, and some development work done, but none of them have yet reached the point of putting their products on the market.

Natural Sodium Sulphate Deposits of Wyoming.*

At the middle and southern edge of the Wyoming oil belt, are situated certain dry lakes, of which Soda Lake, 60 miles west-southwest from the town of Casper, is the most important. Soda Lake occupies the lowest part of a shallow depression in a long valley which is bounded on the north by the Sweetwater or Granite Mountains, and on the west and south by the Green, Iron and Ferris Mountains, which are outlying spurs of the Rockies. The Sweetwater River, a tributary of the Platte, drains the valley and flows within a mile of the lake

* Abstract of article on the "Solid Sodium Sulphate Lakes of Wyoming," by Dr. Harvey Attfield, in the *Journal of the Society of Chemical Industry*, Jan. 31, 1895.

itself. The first view one has of the soda lake, or "soda placer," as it is called in Wyoming, gives the impression of a snow-covered area, due to effloresced sodium sulphate, for the lake has long since crystallized into a solid mass. In form the lake is an oval, lying west-northwest and east-southeast, with a long diameter of some 3600 ft., and having an area of about 110 acres. A boom or jetty, made of cuttings of sage brush, has been built out nearly 150 ft. on the lake and forms a rough footway over some places which are said to be very soft in warm weather. At these spots, which are termed "springs," but which are probably mere collections of rain or surface water; it is said that a 20-ft. pole will not touch solid ground. Samples collected from different parts of the surface of the lake and from a large hole 12 ft. square and 8 ft. deep beyond the end of the jetty, were analyzed, and the following table shows the composition of some of the samples of this natural deposit:

	Top Crust.	New Deposit.	Old Deposit.
Sodium sulphate (Na_2SO_4)	84.86%	43.93%	32.28%
Sodium carbonate (Na_2CO_3)	6.23	1.00	1.17
Water of crystallization	6.93	53.89	40.70
Sodium chloride	1.55	0.77	0.45
Sand	0.25	0.17	24.18
Chalk, magnesia and trace of iron	0.08	0.16	1.02
Soluble silica	0.10	0.08	0.20
Potassium, lithium, bromides, borates, nitrates	None.	None.	None.

The top crust of the deposit is effloresced sodium sulphate, each pound containing about one ounce of sodium carbonate. Occasionally crystals of potassium sulphate could be separated by crystallization, though none were found in the three samples quantitatively analyzed. By "new deposit" is meant the crystals of sodium sulphate which form when a hole made in the mass fills up with liquid oozings from its bottom or sides, which subsequently solidify. The sample of this new deposit analyzed was evidently almost pure Glauber's salt. Most of the sulphate is practically free from iron, and is quite neutral when tested with litmus. Two other samples, that were damp when unfrozen, yielded rather less than 45% of the solid sulphate on ignition. The sample of "old deposit" had doubtless become effloresced after collection and before analysis, for the bulk of sand-free rock-sulphate yielded 54% to 55% of volatile matter. Unfortunately the wind-storms frequently occurring here contaminate the sulphate with sand.

The dry soda lake consists, it appears, of Glauber's salt with 3% or 4% of crystalline sodium carbonate. The larger proportion of carbonate in the top crust is due to concentration, the top layers crystallizing last. A systematic series of prospect holes dug over the whole surface of the lake showed that the lake contained about six acres of deep soda, instead of 200 acres as locally asserted, the deposit being probably about 15 ft. thick. The following explanation is suggested for the formation of this large mass of sodium sulphate:

A portion of the sodium sulphate, impregnating the soil in this and in other parts of Wyoming, was probably dissolved out by the melted winter snows, collected in clay-bound or other impervious depressions, where summer evaporation caused concentration, and where eventually crystallization took place.

If a pit be dug in the solid sulphate, the hole fills up with a solution which apparently soon becomes solid with what is called "new deposit." This result is probably due to the percolation of rain-water passing through fissures of the bed and becoming saturated with the sulphate which afterward crystallizes out, and not from new soda brought from below or laterally to the lake in any large quantities. The prospectors of these and other soda lakes of this country make an especial point of this supposed continuous increase, but no real evidence is yet forthcoming of any general increase of this kind. If the latter state of things obtained, the lakes would always be increasing in size, which, from all that can be gathered, is not the case. There is no evidence that any streams run into the lake, nor that springs exist. Samples collected from several soda lakes about 15 miles northwest from Casper proved to be almost identical in composition with the soda above described, except that they contained rather less sand.

The total area of this Casper group of lakes was considerably greater than that of the lake first examined. Three deposits or lakes, 15 miles southwest of Laramie City, were worked, until a few years ago, for sulphate. The water covering these lakes in winter is partly derived, it seems, from the leaking of an irrigation canal and partly from several springs. In the winter of 1891 the water on Big Lake was frozen to the depth of 2 in., and on Track Lake to a depth of 5 in. In summer the deposits are evidently quite dry. A spring curiously free from sulphate is situated within a few feet of the soda deposit.

Track Lake when examined was covered with hard, firm ice about 4 in. in thickness. Below this were found some 10 in. of water, and below this again a copious deposit of clear crystals of sodium sulphate, under which the solid vitreous sulphate was found as in the other deposits.

At Big Lake, which is some 70 acres in area, a few holes were cut in the ice, and then by means of a scoop the layer of loose crystals, as characteristic of this as of the other lakes, was found to be as much as 12 to 15 in. in thickness, and the crystals themselves to be particularly clean and bright. A walk all over the lake, driving a rod through the ice every few yards, always gave the same result, namely, first some 2 in. of rotten ice, then about 1 ft. of water with about the same amount of loose crystals, under which came the solid vitreous mass. In only two of numerous probings could be found any variation in these layers. In these two instances no hard mass, and no bottom, could be felt, and the rod came up clayey and smelling of sulphureted hydrogen as in the case of the mud veins of Red Lake.

The Laramie Sodium Sulphate Works, situated about a mile from the town of Laramie, consist of a complete and comparatively modern plant for the manufacture of sodium carbonate and caustic soda. The works have not been operated successfully, it is said, owing to mismanagement.

Until the saline masses can be dried at a low cost on the spot and the resulting dry salt be cheaply conveyed to the glass works, which are the chief consumers of this product, the solidified sodium sulphate lakes cannot be utilized to any great extent, owing to their distance from a market.

MINING STOCKS.

THE general depression in business which began in Europe in 1891, which reached this country in 1893, and which was felt here throughout the whole of 1894, had a most marked effect upon the mining stock markets. Mining stocks are regarded—sometimes with justice, sometimes wrongly—as the most speculative of investments, and a period of stagnation like that which reached its worst during 1894 puts an end to speculation for the time, and sends investors to those representatives of value which are regarded as absolutely secure. Under these circumstances no improvement in the mining stock market was to be looked for until the business recovery began. The course of the Boston and New York stocks is referred to more in detail in the following pages, and to these special reviews we may add here that the San Francisco Stock Exchange showed very much the same course of dullness and inactivity. The returns from the Comstock mines, which furnish the greater part of the transactions in that market, were not encouraging, and there seemed to be a decided disinclination on the part of the investing public to buy stocks, so that the market depended almost solely upon the "inside" trading.

The smaller mining stock exchanges in this country followed the general course of the leading ones, and showed throughout the year a continued dullness and an absence of genuine purchasers, either for investment or speculation; some of them in fact may be said to have almost gone out of existence, an occasional sale of some local stock being the only evidence of vitality which they gave from time to time. The sole exception to this record in the United States was the stock market in Colorado Springs. The important new discoveries at Cripple Creek, and the great revival of gold mining throughout Colorado, the formation of numerous new companies, and the extraordinary prosperity which many of them exhibited, were the sources of an active business in stocks which found no parallel elsewhere, and gave the new exchange a prosperity which its older rivals can hardly hope to equal at present.

Toward the close of the year, however, an increasing interest in gold mining all over the world began to be felt. Increasing sales are recorded in New York and San Francisco during the last month of the year, while the extraordinarily active speculation in the South African gold stocks in Europe make it probable that the mining stock exchanges of the world will show a much better record for 1895 than they were able to exhibit in 1894.

The Boston Stock Market in 1894.

A review of the Boston mining stock market is practically a review of the market for copper stocks, since that class of securities constitutes, both traditionally and actually, the chief part of the mining properties which are dealt in or owned in Boston. During 1894 the prevailing low prices of the metal, both here and abroad, had a depressing influence on speculation and restricted purchases for investment in a marked degree. From time to time efforts were made to create an interest in the copper stocks, but they did not meet with much success, and the accompanying tables will show that prices upon the whole declined, as might have been expected. The exceptional advances were due to some manipulation of the markets.

In speculative activity the Montana group of stocks undoubtedly led. Boston & Montana and Butte & Boston, which are together known as the Montana group, were the great factors in the market, and the transactions in the first aggregated more than those in all the other stocks combined. The resumption of dividends on the part of this company was the favorable point which made it an exception to the general rule of a decline. The company paid dividends of $2 per share during the year, and the extreme fluctuations of its stock were $22 and $33.75, the higher figure being reached in December while the lower was in July. Butte & Boston reached its highest point in September, but lost something later in the year and closed at $11. The unfavorable point in the latter stock is that its directors make no report, and it is almost impossible to ascertain its condition. The Boston & Montana Company makes a full financial report, although its statement is defective with regard to the mining costs and operating results of its mines and plant.

In the Lake Superior mines the fluctuations were not extreme in either direction. Calumet & Hecla, which is always regarded as the leader of these properties, lost somewhat during the year, reaching its highest point at $302 in April and falling to $292 in December. The next largest producer among the lake companies is Tamarack, which is a favorite investment with Boston people, and which held its own and was able to continue its dividends, notwithstanding the large investments it has made in sinking shafts and other exploration work. The Tamarack now has the honor of owning the deepest shafts of any mining company in the world. The highest price paid for this stock during the year was $170 and the lowest $146, the closing being at $151.

Another Boston favorite is the Quincy, which mine has probably the best future of the entire group, when the present price of the stock is considered. The highest price during the year was $131 and the lowest was $80, but from this fall there was a recovery to $100 at the end of the year. An increase of capital from 50,000 to 100,000 shares was made in April, in order to provide funds for the purchase of the Pewabic mine, and the stockholders were given the right to take the stock at par—$25—payments being extended over five years. The rights for the purchase of this new stock sold in December as high as $40.

The non-dividend shares showed greater weakness than those which we have mentioned, the exception being Franklin, which closed in December at $15.50, an advance of $4.50 over the January price. This was due partly to the success of the company in securing the old Peninsular mine, largely extending its terri-

tory for future work, and partly because of a decision in the old Pewabic suit which will add to the Franklin assets some $40,000, which was not expected. Kearsarge was rather a favorite in speculative circles and there have been many reports, both favorable and unfavorable, concerning developments in the mine, which did not, however, prevent a decline. Centennial experienced the greatest fall of any company, and at the end of the year stood at 75c. per share. This was owing to the failure to find paying ore in the mine.

Of the other copper stocks not much is to be said. Wolverine and Tamarack, Jr., were but little dealt in, while the minor list, such as Allouez, Arnold, Ridge, and the rest, were only occasionally mentioned.

Outside of the copper stocks very little was done during the year in the Boston market. Napa Quicksilver, which is a regular dividend payer, was occasionally quoted, but it is held chiefly for investment. The silver stocks, which were once favorites in Boston, were neglected entirely.

FLUCTUATIONS OF MINING STOCKS AT BOSTON DURING 1894.

Name and Location of Company.	Par Value.	January.		February.		March.		April.		May.		June.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Allouez, Mich.	$25	.50	.....	.....	.....	.45	.....	.40	.25	.40	.09	.25	.09
Arnold, Mich.	25	.....	.....	.....	.....	.....	.....	.75	.....	.75	.....	.....	.....
Atlantic, Mich.	25	12.63	9.50	9.75	9.00	10.25	9.50	10.25	9.25	9.50	7.50	8.50	7.25
Bonanza, C. & M.	10	.....	.....	.....	.....	.....	.....	.25	.20	.....	.....	.....	.....
Boston & Montana, Mont.	25	28.25	24.00	26.00	21.50	27.63	21.50	29.00	25.00	27.00	24.00	26.00	23.38
Butte & Boston, Mont.	25	10.00	8.50	9.00	8.25	.....	.....	11.50	9.50	10.13	9.00	9.38	8.75
Calumet & Hecla, Mich.	25	302.00	297.00	300.00	293.00	305.00	292.00	202.00	200.00	295.00	270.00	275.00	269.50
Catalpa, Colo.	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Centennial, Mich.	25	5.00	3.25	4.38	3.13	.....	.....	3.75	2.50	3.00	.80	1.25	.75
Central, Mich.	25	.....	.....	.....	.....	.....	.....	9.75	9.00	.....	.....	.....	.....
Franklin, Mich.	25	11.00	9.13	10.00	9.00	10.00	9.50	.....	.....	9.00	7.50	8.60	8.00
Kearsarge, Mich.	25	8.00	6.75	7.13	6.00	8.50	6.50	8.50	6.50	6.50	6.00	6.00	5.00
Lake Superior Iron.	.....	.....	.....	22.00	.....	22.50	.....	.....	.....	.....	.....	.....	.....
Napa, Cal.	2	.....	.....	4.75	.....	.....	.....	.....	.....	5.00	.....	5.13	4.75
Osceola, Mich.	25	29.50	25.00	27.00	24.75	.....	.....	26.75	22.00	25.00	20.50	21.00	18.50
Pontiac, Mich.	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Quincy, Mich.	25	125.00	120.00	125.00	115.00	129.00	125.00	96.00	80.00	92.00	86.50	88.00	84.00
Quincy Scrip.	.....	.....	.....	.....	.....	28.50	22.00	35.00	22.00	30.00	29.00	29.50	28.00
Tamarack, Mich.	25	161.00	155.00	160.00	157.00	.....	.....	.....	.....	170.00	155.75	163.00	156.00
Tamarack, Jr., Mich.	25	20.50	18.00	19.00	17.00	18.25	15.00	16.50	14.75	15.00	.....	.....	.....
Wolverine, Mich.	25	2.75	1.75	1.75	1.50	2.10	1.25	2.50	1.75	1.88	1.50	1.50	1.00

	July.		August.		September.		October.		November.		December.		Sales.
	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	
Allouez, Mich.	.....	.....	.....	.....	.30	.25	.....	.....	.....	.....	.....	.....	10,775
Arnold, Mich.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	800
Atlantic, Mich.	8.50	.....	10.00	8.50	11.25	10.25	10.25	10.00	10.00	9.75	11.50	11.00	5,055
Bonanza, C. & M.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	100
Boston & Montana, Mont.	23.38	21.00	28.00	21.50	31.50	26.75	30.00	28.00	30.75	28.50	33.75	29.50	100,778
Butte & Boston, Mont.	8.75	8.25	10.75	8.25	11.63	9.50	11.50	10.00	10.88	10.00	11.25	10.50	76,981
Calumet & Hecla, Mich.	278.00	270.00	292.00	276.00	393.00	290.00	295.00	290.00	295.00	280.00	290.00	286.00	1,744
Catalpa, Colo.	.....	.....	.10	.....	.....	.....	.....	.....	.10	.....	.....	.....	800
Centennial, Mich.	1.25	1.00	1.25	.75	1.13	.90	1.25	.85	.75	.50	.....	.....	21,441
Central, Mich.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	80
Franklin, Mich.	8.50	8.00	.....	.....	10.75	9.00	12.50	10.00	12.75	10.00	15.63	12.50	11,205
Kearsarge, Mich.	5.00	4.50	7.50	4.75	8.00	6.00	7.50	6.25	7.50	7.00	7.75	7.00	8,869
Lake Superior Iron.	.....	.....	.....	.....	.....	.....	.....	.....	22.00	21.63	.....	.....	400
Napa, Cal.	5.00	4.75	4.75	.....	5.00	4.88	5.00	.....	5.00	.....	5.50	5.25	2,945
Osceola, Mich.	19.00	18.25	25.00	18.18	25.75	22.75	25.00	22.00	23.00	19.00	22.75	21.00	22,268
Pontiac, Mich.	.....	.....	.....	.....	.....	.....	35	.....	.....	.....	.....	.....	1
Quincy, Mich.	84.00	80.00	94.50	80.00	95.00	90.00	94.00	90.00	95.00	92.00	105.00	93.00	4,410
Quincy Scrip.	29.00	27.10	36.00	28.50	36.00	33.00	36.50	34.00	35.00	34.00	42.00	34.50	5,589
Tamarack, Mich.	158.00	152.00	169.00	154.00	168.00	160.00	164.50	149.00	153.00	146.00	161.00	151.00	5,872
Tamarack, Jr., Mich.	11.00	10.00	14.00	10.50	12.50	10.00	11.50	10.00	11.26	10.00	11.50	10.50	4,199
Wolverine, Mich.	1.25	.....	2.25	1.25	3.25	2.25	3.00	2.25	3.85	2.75	3.00	2.75	27,143
Total shares sold.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	311,455

The Mining Stock Market in New York.

The condition of the mining stock market in New York may be summarized very briefly by calling attention to the total number of shares sold during 1894, given in the accompanying table; that total was 302,372 shares, being less than half the similar total shown in the very dull year of 1893. The enormous decrease in the amount of transactions on this market will be shown further by the fact that while the number of shares sold in 1894 was 302,372, as stated above, in 1893 the record shows 624,617 shares; in 1892 there were 1,527,371 shares; 2,522,660 shares in 1891; 3,925,926 shares in 1890; 4,114,480 shares in 1889, and 11,689,388 shares in 1888.

These figures will show better than any words the decline of the mining stock market in New York, and perhaps little explanation is needed to those who are

FLUCTUATIONS OF MINING STOCKS AT NEW YORK DURING 1894.

No.	Name and Location of Company.	Par Value.	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.	
			H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
1	Alice, Mont.	$25															.25	
2	Alpha, Nev.	100			.20		.25	.15										
3	Alta, Nev.	100	.20		.20	.15			.38	.35	.57		.22		.25		.27	.22
4	American Flag, Colo.	100					.05		.05		.04	.03	.04	.03	.02			
5	Andes, Nev.	100					.29											
6	Barcelona, Nev.	25							.09								.95	
7	Belcher, Nev.	100	1.00	.70	1.00													
8	Belle Isle, Nev.	100					.05											
9	Best & Belcher, Nev.	100	2.45	1.90	2.25	1.80	2.15	1.25	2.25	1.55	2.70	2.00	1.95	1.05	1.15	1.10	1.55	1.10
10	Bodie, Nev.	100	.30	.25	.28	.25	.17	.05	1.20	.08	1.40		1.40	1.05	1.00		1.35	1.00
11	Brunswick, Cal.	5	.06	.05			.02		.04								.01	
12	Bullion, Nev.	100	.20															
13	Bulwer, Cal.	100			.05				.17	.15	.45	.20	.15	.04	.16	.15	.25	.15
14	Castle Creek, Ida.	100							.03									
15	Chollar, Nev.	100	.55	.50	.65	.47	.60						.35	.30	.50	.29	.40	.34
16	Chrysolite, Colo.	50	.20						.20									
17	Comstock Tun., Nev.	100	.08	.07	.09	.07	.09	.07	.09	.07	.09	.05	.07	.05	.04	.03	.04	.03
18	" Bonds, "								.07		.06							
19	" Scrip, "								.10									
20	Cons. C. & Va., Nev.	100	4.15	2.95	4.50	2.85	4.15	2.10	7.00	2.30	8.25	5.63	5.63	2.75	3.45	2.90	4.80	2.80
21	Cons. Imp., Nev.	100	.11	.10	.24	.10	.21	.15					.09				.06	
22	Crown Point, Nev.	100	.55	.45	.85	.40			.70						.90		1.00	.80
23	Deadwood Ta., S. Dak.	25							.80	.65	.50		.50					
24	El Cristo, Rep. of Col.	2			.10													
25	Eureka Cons., Nev.	100			.20				.90	.20	.50	.30						
26	Exchequer, Nev.	100			.30													
27	Gould & Curry, Nev.	100	1.15	.90	.95	.55	.95	.85	.85				.95		.60		.67	.54
28	Hale & Norcross, Nev.	100	.85		.75	.50	.75	.60	.75	.50	1.20		1.65		.68			
29	Homestake, S. Dak.	100	12.50				14.50								3.05		3.00	2.80
30	Horn Silver, Utah.	25	2.75		3.75	2.90											.05	
31	Julia Cons., Nev.	100																
32	Lacrosse, Colo.	10	.04		.05	.04	.07	.06	.05		.04		.05	.04				
33	Leadville, Colo.	10	.13	.12	.12	.11	.11	.10	.11	.08	.09	.07	.10	.08	.10	.08	.10	.09
34	Little Chief, Colo.	50					.12	.10	.14	.11	.15	.10	.15	.14	.15		.15	
35	Mexican, Nev.	100	1.20	1.00	1.85	1.05	1.70	1.40	1.80	1.40	2.35	1.80	1.40	.65	1.00	.65	1.45	.95
36	Mono, Cal.	100							.50						.30		.39	.20
37	Moulton, Mont.	5	.25		.25		.20											
38	Ontario, Utah.	100	7.00	6.25	8.13	7.88												
39	Ophir, Nev.	100	2.25	1.50	3.30	1.25	2.80	2.20	3.50	2.55	3.50		3.15	1.05	2.00	1.75	2.70	2.35
40	Overman, Nev.	100			.55	.30	.30	.10	.10									
41	Phœnix of Arizona.	100	.30	.26	.30	.22	.30	.12	.17	.12							.12	
42	Plymouth, Cal.	50	.25				.25											
43	Potosi, Nev.	100	.60		.50		1.30	.70	1.20	1.00							.55	
44	Quicksilver, Cal., com.	100			3.00	2.00	2.88											
45	" " pref.	100			17.00	16.00	17.75	17.25										
46	Robinson, Colo.	50	.32															
47	Savage, Nev.	100							.70				.45		.42	.35	.45	.35
48	Sierra Nevada, Nev.	100			1.30	.85	1.45	1.25	1.45	.50	1.90	1.20	1.05		.60		.80	.70
49	Silver King, Ariz.	100					.25											
50	Standard Cons., Cal.	100			1.00	.85	1.50	1.10	1.85	1.40	1.85	1.60	1.80	1.70			1.55	1.40
51	Union Cons., Nev.	100	.95	.80	1.00	.65	1.00	.10	1.00	.90	1.50	.95	.65	.45	.55	.37	.60	.55
52	Utah Cons., Nev.	100			.62				.10	.07							.10	
53	Victor, Colo.	5													2.85	2.75	3.00	2.80
54	Yellow Jacket, Nev.	100	1.10	.85	1.15	.75	.85	.22	.80	.65	1.20	1.00	1.00	.45	.55	.40	.60	.46
	Total sales.																	

familiar with the condition of affairs which prevailed when the market was at the height of its prosperity. In addition to the reasons found in the character of many of the stocks which were then dealt in and unloaded upon the public, there is the further reason that the method of placing mining properties has very much changed during these years, and that valuable mines are more often sold and organized without reference to the placing of stock upon the market, the holders preferring to retain the control in their own hands and operate the company as a private concern. The change does not, therefore, mean that investment in mining properties has ceased, but that mining stocks are no longer favorite counters in the speculative world, which is now largely supplied with stocks of other descriptions for that purpose.

At the close of 1894 there were 134 mining companies whose stocks were listed on the Consolidated Exchange in New York. These tables will show that only 54 of these were dealt in at any time through the year, and in quite a number of these there were only a few transactions. The active list is limited practically to the Comstocks and a few other Nevada companies, with a short list of South Dakota companies, and to perhaps half a dozen from Colorado and California. In the Comstocks especially the dealing in New York depends upon and follows closely the San Francisco market, and only in a very few cases can the prices be said to be made in New York, or by the sales in that city.

The only new stock listed during the year was that of the Victor Gold Mining Company, of Cripple Creek, Colo., in May.

The course of prices during the year has been very irregular; so much so that hardly anything can be predicated upon the figures. While many fluctuations are shown, it cannot be said that there was any regular increase or decrease, nor that the December quotations show, upon the whole, any lower averages than those in January. The absence of buying for investment, and the continued dullness in speculation of all kinds, made the market an exceedingly uninteresting one throughout the year.

FLUCTUATIONS OF MINING STOCKS AT NEW YORK DURING 1894—*Continued.*

Sept.		Oct.		Nov.		Dec.		Sales.	No.
H.	L.	H.	L.	H.	L.	H.	L.		
....	....	....	....	....	....	....	....	100	1
....	....	....	....	....	....	....	....	300	2
....	....	....	....	....	....	.19	....	5,700	3
....	....	.03	.02	.03	....	.04	....	6,100	4
....	....	....	....	....	....	....	....	1,000	5
....	....	....	....	....	....	....	....	100	6
.85	....	....	....	....	....	....	....	600	7
....	....	....	....	....	....	....	....	100	8
1.70	1.30	1.90	.98	1.25	1.10	.95	.48	7,676	9
1.60	1.45	1.60	1.25	1.25	.80	.76	.57	5,650	10
.01	....	.04	....	....	....	.05	.04	5,580	11
....	....	....	....	....	....	.31	....	200	12
.19	.17	.12	....	....	....	.05	....	6,700	13
....	....	....	....	.02	....	....	....	2,200	14
.68	.24	.86	.61	.79	.60	.60	.49	13,086	15
....	....	....	....	....	....	....	....	1,300	16
.07	.05	.07	.05	.07	.06	.06	.04	115,066	17
.04	....	....	....	.08	....	.10	.08	12,013	18
.15	....	....	....	....	....	....	....	500	19
5.75	4.00	6.50	4.70	4.90	3.75	3.95	2.75	21,237	20
.10	.06	....	....	....	....	....	....	9,300	21
....	....	.86	.80	.80	....	.75	.65	2,410	22
....	....	....	....	....	....	....	....	2,700	23
....	....	....	....	.03	....	....	....	300	24
....	....	....	....	....	....	....	....	2,180	25
....	....	....	....	....	....	....	....	100	26
.85	.65	1.10	.70	.70	....	.50	.45	3,440	27
.75	.50	1.25	.95	1.35	.90	1.20	.67	6,400	28
....	....	....	....	....	....	....	....	200	29
2.30	....	....	....	2.25	....	....	....	970	30
....	....	....	....	....	....	....	....	200	31
....	....	.06	.04	.07	.05	.09	.06	25,200	32
....	....	.11	.08	.11	.10	.10	....	26,000	33
.15	....	.15	....	.15	.13	....	....	10,800	34
1.90	1.15	1.90	1.10	1.25	.88	.70	.62	2,200	35
.33	....	.25	....	....	....	....	....	11,370	36
....	....	....	....	....	....	....	....	1,750	37
....	....	....	....	10.00	....	10.00	....	2,075	38
4.25	2.60	4.25	2.70	3.30	2.70	1.65	1.55	7,450	39
....	....	....	....	....	....	....	....	1,700	40
.10	....	.20	.11	.16	.14	.14	....	15,900	41
....	....	.35	....	.30	....	.30	....	3,800	42
.50	....	.95	.70	.80	.60	.39	.38	2,124	43
....	....	....	....	....	....	1.88	....	3,445	44
....	....	....	....	....	....	....	....	800	45
....	....	....	....	....	....	....	....	300	46
.83	.70	.70	.60	.74	.55	.40	.35	5,300	47
1.35	1.15	1.45	1.00	.91	.60	.68	.60	8,670	48
....	....	....	....	....	....	....	....	300	49
1.20	....	....	....	1.25	....	1.90	....	9,100	50
1.20	.70	1.15	.74	.70	.65	.41	.32	6,630	51
.12	.10	.21	.16	....	....	.15	....	3,800	52
3.00	....	....	....	....	....	2.75	....	7,150	53
1.35	.70	1.35	.71	.76	.54	.58	.42	13,100	54
....	....	....	....	....	....	....	....	402,372	

The Coal Stocks on the New York Market.

The prices of coal stocks on the New York market generally showed a decline in 1894, which was partly due to the general weakness of all speculative values, and partly to the special circumstances affecting the coal market, such as light demand, low prices, strikes, etc. A few companies, whose stocks are steady investments, showed no change, and one or two, like Morris & Essex, on which the returns are guaranteed by lease, actually made some improvement. Toward the close of the year the anthracite companies' stocks were affected by the disturbed condition of the anthracite trade, closing considerably below the highest point of the year.

The companies mining and carrying bituminous coal do not make as prominent a feature of the New York stock market as the anthracite companies; but those which are dealt in followed the same general course.

PRICES OF COAL STOCKS AT NEW YORK DURING 1894.

Name of Company.	Par Value.	January.		February.		March.		April.		May.		June.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
American Coal	$25	.....	.....	.....	.....	.....	.....	.....	.....	82.00	.....	.....	.....
Col. & Hocking Coal	100	7.00	6.50	8.00	6.50	9.50	7.13	9.75	7.50	7.00	6.50	7.50	7.50
Colo. C. & I.	100	10.75	10.00	8.00	6.50	11.00	9.00	13.50	12.50	.....	.....	7.00	5.00
Colo. Coal, Fuel & Iron	100	26.50	21.00	26.50	26.00	25.50	.....	27.50	25.00	.....	.....	25.50	20.00
" " " pref.	100	60.00	59.00	.....	.....	.....	.....	70.00	68.00	70.00	.....	.....	.....
Consolidation Coal	100	30.00	.....	.....	.....	31.00	.....	.....	.....	30.50	28.00	.....	.....
Del. & Hudson Canal	100	136.00	129.25	138.00	135.00	139.75	135.25	144.50	137.50	140.13	131.50	132.00	129.25
Del., L. & W. R. R.	50	170.50	161.25	169.38	165.50	167.63	166.00	167.00	161.50	162.00	158.00	161.50	159.59
Hocking Valley & Tol.	100	20.50	19.00	47.00	45.00	20.88	18.75	20.50	17.13	18.25	16.13	18.38	16.25
Hunt. & Broad Top	50	35.00	33.00	31.75	.....	32.00	.....	30.00	29.75	.....	.....	.....	.....
" " " pref.	50	52.00	50.00	50.63	48.00	50.00	49.13	49.75	48.00	50.00	48.00	50.00	49.75
Lehigh Coal & Nav.	50	53.00	51.75	53.00	51.50	55.00	53.25	54.50	53.75	54.00	50.00	51.50	50.75
Lehigh Valley	50	39.75	36.50	40.25	39.00	42.88	39.13	40.25	37.00	38.00	36.00	38.63	37.00
Morris & Essex	100	151.75	148.00	150.00	149.88	154.75	151.00	156.00	152.00	157.00	155.00	153.38	151.25
New Central Coal	50	.....	.....	.....	.....	8.50	8.00	8.50	8.00	8.50	.....	.....	.....
N. J. Central R. R	100	116.75	111.00	115.50	114.25	117.75	114.50	115.00	110.13	111.00	108.00	107.50	105.00
N. Y., Susq. & West	100	15.88	14.00	16.50	15.25	16.63	15.75	16.25	15.13	15.25	13.88	15.75	14.38
" " " pref.	100	45.00	40.00	46.00	44.50	46.75	44.50	45.25	43.75	40.88	36.00	41.50	39.50
Norfolk & West. R.R.	50	.....	.....	4.75	4.25	7.00	5.50	7.50	6.50	6.00	5.00	.....	.....
" " " pref.	50	20.00	17.63	21.50	20.00	24.25	20.00	26.00	21.75	21.50	20.00	21.25	17.88
Pennsylvania Coal	50	.....	.....	300.00	298.00	310.00	300.00	310.00	.....	.....	.....	315.00	.....
Pennsylvania R. R.	50	50.00	48.00	49.88	49.00	52.13	49.00	52.13	51.00	50.88	48.75	49.50	48.50
Phila. & Reading R. R.	50	21.00	17.25	22.13	20.00	23.38	20.88	22.25	18.88	19.00	14.88	17.75	14.88
Tennessee C. & I.	100	17.00	14.13	9.00	8.00	20.25	19.00	20.00	16.50	18.00	16.00	20.25	17.25

Name of Company.	July.		August.		September.		October.		November.		December.		Sales.
	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	
American Coal	90.00	88.00	.....	.....	.....	.....	90.00	.....	90.00	88.00	87.00	.....	995
Col. & Hocking Coal	7.50	6.50	9.25	7.13	7.63	7.63	6.50	5.25	7.25	6.00	5.25	5.00	16,927
Colo. C. & I.	7.25	7.25	.....	.....	9 88	9.00	10.00	7.00	.....	.....	9.00	4.75	6,917
Colo. Coal, Fuel & Iron	.....	.....	25.00	.....	24.00	.....	23.00	22.00	26.50	23.50	26.50	26.00	18,288
" " " pref.	.....	.....	.....	.....	70.00	.....	.....	.....	72.00	.....	75.00	72.00	850
Consolidation Coal	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	31.50	.....	885
Del. & Hudson Canal	133.50	125.00	136.75	133.00	137.00	134.00	135.63	119.25	129.25	122.50	127.63	123.00	184,882
Del., L. & W. R. R.	164.38	158.50	167.50	162.00	174.00	168.00	171.38	155.25	162.00	156.00	163.00	158.00	101,529
Hocking Valley & Tol.	17.25	15.50	19.38	17.00	19.75	18.50	19.00	17.75	19.25	17.00	18.00	16.75	34,202
Hunt. & Broad Top	33.50	31.00	33.00	32.00	37.25	32.50	.....	.....	34.88	34.00	36.00	34.75	4,095
" " " pref.	52.00	51.00	50.50	50.00	52.00	50.00	51.50	51.25	53.00	50.75	54.00	52.50	3,655
Lehigh Coal & Nav.	51.25	50.00	52.00	50.50	52.00	51.00	52.25	51.25	51.38	46.50	49.00	46.25	12,118
Lehigh Valley	38.63	36.25	40.00	37.38	39.25	37.50	38.00	36.38	36.50	33.00	37.00	33.25	60,257
Morris & Essex	154.75	153.00	154.60	.....	160.00	158.75	160.50	159.75	162.00	160.00	163.00	161.50	6,550
New Central Coal	.....	.....	.....	.....	6.50	.....	.....	.....	.....	.....	6.25	.....	905
N. J. Central R. R.	107.00	106.25	116.00	106.50	115.50	111.50	111.00	90.50	98.13	89.75	94.50	87.50	51,987
N. Y., Susq. & West	15.13	13.75	17.25	14.25	17.50	16.38	17.00	13.63	16.50	14.50	15.63	14.25	58,599
" " " pref.	40.75	38.50	45.13	39.75	48.00	43.00	45.50	41.00	46.00	41.75	42.75	42.00	60,321
Norfolk & West. R.R.	4.13	4.00	8.25	4.25	9.50	7.88	8.50	6.88	8.00	6.50	6.75	5.38	37,210
" " " pref.	.....	.....	26.00	20.50	26.75	24.63	24.13	22.00	23.25	22.00	26.75	17.00	18,530
Pennsylvania Coal	.....	.....	.....	.....	300.00	.....	.....	.....	300.00	275.00	.....	.....	604
Pennsylvania R. R.	49.25	48.00	51.25	48.88	52.63	51.50	52.00	51.38	51.50	50.13	51.50	50.25	121,465
Phila. & Reading R. R.	18.13	15.75	22.63	17.00	22.88	17.25	20.13	16.50	18.63	15.25	16.75	13.50	1,324,515
Tennessee C. & I.	19.25	16.88	19.25	17.00	19.25	18.00	18.75	14.00	17.00	14.50	17.50	15.00	150,944
Total shares sold	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2,277,230

The London Mining Stock Market in 1894.

While the amount of mining business transacted on the London Exchange during the year 1894 was not very much greater than during that worst of all years, 1893, the feeling in financial, speculative, and mining circles was much more hopeful, and greater inclination to open up speculation and to consider new prospects was evinced. During the three years ending with 1893, both legitimate business and speculation gradually became worse, and at the time that the report for The Mineral Industry, Vol. II., was written, prospects looked about as black as they possibly could. The wave of depression was checked in January, 1894, however, and since then there has been some improvement. During February, March, and April strenuous efforts were made in London to initiate new mining speculation, and with success for a time; but the old dullness returned during the summer months. In the autumn a genuine improvement set in, and the booms in West Australian gold mines, and in South African gold stocks, kept brokers, promoters, and capitalists fairly busy. During the months of November and December the speculation in South African gold stocks has been the feature of the Stock Exchange, all other departments being entirely neglected. The amount of business transacted was enormous, and probably exceeded all previous records.

The influence of the silver question on mining remained practically unchanged throughout the year. As the price of the metal wavered between the comparatively narrow limits of 27d. and 30d. and the changes were not abrupt, no chance was given for speculation of any sort, while the prospect that low prices would continue made it perfectly useless to attempt to float a new silver mine either privately or publicly.

The great event of the year was the introduction of West Australian mines on the London market. The first signs of this movement were in November, 1893, when the Mallina gold mine was floated. During the first eight months of the year 1894, eighteen companies, with an aggregate capital of £855,000, made their appearance. The beginning of the boom came in September with eight companies, with an aggregate capital of £795,000, and these were followed in October by seventeen companies with an aggregate capital of £1,450,000, in November by sixteen companies with a total capital of £1,900,000, and in December by five companies with an aggregate capital of £850,000. During September and October the public showed an inclination to go freely into these companies, but since then the strictures of the press on the methods pursued by the promoters, and the reports of the variable character of the gold-bearing rock, have combined to check speculation; and it is with the greatest difficulty with the help of underwriters that companies are floated at the time of writing.

The Transvaal gold mining industry goes on with great regularity and the shares of the best companies are treated as investments and not speculations. The output of the Witwatersrand by months has been 149,814 oz., 151,870 oz., 165,372 oz., 168,745 oz., 169,773 oz., 168,163 oz., 167,953 oz., 174,977 oz., 176,707 oz., 173,378 oz., 175,304 oz., and 182,104 oz.; a total of 2,024,159 oz. as compared with 1,478,473 oz. in 1893 and 1,210,868 oz. in 1892.

The settlement of the difficulties in Matabeleland was finally accomplished during 1894, and explorations are being conducted with great energy. A large

number of development companies have been formed, but the time has not yet arrived for reporting definitely on the country.

An important event of the year relating to mining was the judgment of Justice Romer, in chancery, that the MacArthur-Forrest cyanide patent was not good in law. The decision has been appealed from, so that the matter is still in an undecided state.

The department of American mines continued to shrink, and is now so much neglected that there is no broker who makes it his specialty. Not a single new company was introduced to the public during the year, though a small number of American properties were subscribed for privately. Two companies floated in previous years, the Alaska-Mexican, Alaska, floated in 1892, and Twin Lake Placers, Colorado, floated in 1892, came into notice in 1894 and business in their shares warranted quotations in brokers' lists. The most noteworthy events of the year in the American mining stock market were the resumption of the payment of dividends by the Montana Company, and the great Poorman case. In the following paragraphs a resume is given of the principal operations and alterations in American mining stocks managed in London:

The Poorman Consolidated Mines, a New Jersey corporation formed in 1893 to take over the English company, the Poorman Mines, Limited, and the American companies, the South Poorman Mines, and the Idaho Milling Company, has been in difficulties during the whole year. The *Engineering and Mining Journal* had reason for attacking the management of this corporation in its columns in the early part of the year, and the directors commenced a lawsuit for libel against the owners of the *Journal*. It has been decided, however, to wind up the corporation and transfer the property to an English company, and at the same time to suspend the legal proceedings; thus the full facts of the case will never come to light. The new mill which had been erected for the Poorman Consolidated was burned down from some unexplained cause in July, and the directors are now engaged in raising further capital with which to construct a new plant. The shares of the company have been practically unsalable during the year, owing to the uncertainty as to the future of the company.

The Montana Company has at last recovered its position among the dividend payers. After paying dividends from 1884 to 1891 it was found necessary to reconstruct so as to provide further capital. Owing to the very expensive lawsuit and the diminution of the value of the ore bodies, the reconstructed company made heavy losses, and the silver crisis in 1893 threatened to prevent the recovery of the company to a paying basis. Fortunately, however, the lawsuit came to an end and new ore bodies of considerable value were discovered during the early months of 1894; these facts, combined with the admirable management of Mr. Bayliss, have put the balance once more on the right side, and a dividend of 6d. per £1 share was declared on the capital—£660,000—in December.

The De Lamar Mining Company has strengthened its position during the year, and its stock is one of the best to be found on the London mining market. In the summer a disturbance took place on investors finding out that all development operations had been discontinued after the silver crisis of 1893, but confidence was soon restored on the announcement that they had already three years' ore in sight and that the development work was to be continued in the autumn of the

year. A severe slump in the stock occurred during the summer, owing to an insider selling large blocks of his holdings, but when it was discovered that he was not actuated by fears of the future of the mine, but by shortness of ready cash, confidence was soon restored. The directors in November opened an agency in Paris and issued bearer shares in place of registered shares, in order to make a market for the stock on the continent of Europe. So far this movement has met with great success.

The Harquahala Gold Mining Company has not turned out so great a success as the promoters expected. A first dividend was paid in November, 1893, on the result of the first three months' operations, but almost immediately afterward work was stopped on account of the condition of the main shaft. A good deal of repairing and development work had to be done and it was not until 1894 that it was so well advanced that the mill could be restarted. The shares which had stood very near par—£1—in November gradually sank to 5s., at which they stood during most of 1894. The ore bodies have been proved to be leaner than investors were given to suppose, but with careful management dividends of 10% per annum may be paid for some years, and during the autumn of 1894 the payment of dividends was resumed at this rate.

The Springdale Gold Mining and Milling Company, a Denver corporation whose shares were placed on the London market during 1893, has not been able to do much with the telluride ore which the company was formed to work. The property is now pretty much in the hands of the English shareholders and A. L. Pearse has been appointed by them to manage it. He has bought ordinary gold claims for them, and these will have to be relied on for the main part of the future dividends.

The Palmarejo Company of Mexico is in an almost hopeless state. The whole of the year has been spent in quarreling over the terms of the proposed amalgamation with the Mexican Mineral Railway Company, and the prospects of an amicable settlement seem as far off as ever. The actual condition and prospects of the mine have been entirely lost sight of during this quarrel, but according to the periodical reports it is being worked at a profit.

The Alaska-Treadwell Mine has continued paying dividends regularly out of the low grade ores, and the stock of this company, as well as that of the Alaska-Mexican, which has come into operation during 1894, have been in demand during the year.

Of other American mines little can be said, and their present position may be summed up in a sentence each. Work on Sierra Buttes and Plumas Eureka mines is going on in exactly the same way as a year ago. The Elkhorn and Jay Hawk mines are being worked as long as the silver ores can be handled at a profit. The Richmond Consolidated Company has not yet decided on a new property. Two reconstructed companies, Holcomb Valley and the Mexican Silver Mines of La Luz, have not made any advance since last year's report was written. Exactly the same can be said of Golden Feathers and Golden Gates during 1894 as during 1893. Yankee Girl has gone out of existence and American Belle is apparently on the same road. Gustons are in a more hopeful condition and there is some likelihood of the mine becoming a dividend payer again. Golden Leaf, Emma, and Idaho have suspended operations in America

and are turning their attention to West Australia. The New Eberhardt Company has given up its American property and has purchased a mine in South Africa, at the same time changing its name to the Thistle Reef Company.

The following new companies formed to deal with American mining properties have been registered during 1894:

UNITED STATES.

Berkin Gold and Silver Extraction Company, with a capital of £25,000, to work under United States patent No. 494,054.

California Gold Production Syndicate, with a capital of £55,000, to buy the property of the St. Charles Hill Gold Mining Company.

Californian Electric Power and Mining Development Syndicate, with a capital of £30,000, with a variety of objects.

Colorado Mining Syndicate, with a capital of £500, object not specified.

Eastern Oregon and General Syndicate, with a capital of £2000; a reconstruction of the Eastern Oregon Gold Mining Company.

Kentucky Timber, Coal and Land Company, with a capital of £40,000, to work timber and coal properties in Laurel and Pulaski Counties, Kentucky.

Lucille Gold Mining Company, with a capital of £200,000, to acquire the Lucille gold mine, near Plymouth, Amador County, California.

Madison Gold Mining Company, with a capital of £85,000, to work the Remington group of mines in Madison County, Montana.

Nevada Nickel Syndicate, with a capital of £10,000, object not specified.

North Carolina Syndicate, with a capital of £20,000, object not specified.

Oregon Gold Mining Syndicate, with a capital of £1500, to search for minerals in Oregon.

Pioneerville Gravel Gold Company, with a capital of £60,000, to work properties on Grimes Creek, Boise County, Idaho.

Sherlock Gold Mines, with a capital of £60,000, to acquire mines in Whitlock district, Mariposa County, California.

Southern States Exploring and Finance Syndicate, with a capital of £20,000, object not specified.

Trinity Gold Placer Mining Syndicate, with a capital of £10,000, to acquire mines in California.

Tucson Mining and Smelting Syndicate, with a capital of £20,000; a reconstruction of the Canada del Oro Mine.

War Eagle Syndicate, with a capital of £2000, to develop mines in Idaho.

CANADA.

Canadian Mica Company, with a capital of £90,000, to work mica mines at Frontenac, Ontario.

Cariboo Gold Fields, with a capital of £100,000, to work the Whittier gold concessions, British Columbia.

Halifax Mining Syndicate, with a capital of £1200, to deal in coal and other properties in Nova Scotia.

Lillooet (Cariboo) Gold Mine, with a capital of £24,500, to acquire gold claims near Lillooet, Cariboo, British Columbia.

Nova Scotia Gold Mines, with a capital of £35,000; a reconstruction.

MEXICO AND CENTRAL AMERICA.

Guadalupe (Honduras) Gold and Silver Mining Company, with a capital of £70,000; a reconstruction.

Lyonnaise Mexican Concessions, with a capital of £200,000, to work mines at Tlalpujahua, Mexico.

New Guayabillas Mining and Reduction Company, Honduras, with a capital of £31,000; a reconstruction.

Santa Francesca Gold Mines, Nicaragua, with a capital of £300,000.

SOUTH AMERICA.

British Guiana Development Syndicate, with a capital of £10,000, to work claims on the Demarara River.

British Guiana Gold Fields, with a capital of £50,000, object not specified.

Brazilian Gold Exploring Syndicate, with a capital of £20,000.

Central Chile Copper Company, with a capital of £255,000; a reconstruction of the Panulcillo Copper Company.

Don Pedro Gold Mines, Brazil, with a capital of £150,000; a reconstruction.

Fernandez Mines Syndicate, with a capital of £3000, to explore and develop alluvial properties in the Republic of Colombia.

Gurupy Gold Mining Company, Brazil, with a capital of £100,000.

Martinez Gold Mine Syndicate, to develop mines in South America.

Nine Mines of Novita, with a capital of £30,000, to work auriferous river beds in the Republic of Colombia.

Pelaez Silver Mines, with a capital of £106,720, to acquire the silver mines of the Bolivian Silver Company.

The Paris Mining Stock Market.

On the Paris Bourse the speculation in the old established stocks was comparatively limited throughout the year; during the latter half of the year, however, a very active interest was developed in the South African mining stocks, large purchases of which were made from London both for investment and for speculative use. The amount placed in these shares by French holders has been variously estimated. As the transactions were made chiefly through London brokers it has been difficult to determine it exactly, but good judges estimate it at no less than 50,000,000f.

Early in the year the De Lamar Mining Company of Idaho, made arrangements for the registry of its stock in Paris with a view to having it dealt in there. Considerable sales of stock followed, and toward the end of the year it is understood that a controlling interest in this prosperous company passed into French hands. It is said that steps may be taken to introduce other American stocks in Paris also.

Generally speaking, it may be said that the coal and iron stocks dealt in the most were comparatively inactive. The stocks of the copper companies were generally depressed, owing to the continued low prices of the metal ; in one or two cases, however, they were supported by special influences. In the old established zinc and lead stocks there were some fluctuations from time to time, but little total change. The silver stocks were almost totally neglected.

DIVIDENDS PAID BY AMERICAN MINES. (1 = $1000; total, full amount.)

Company.	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	Total.
Adams, S., L., Colo	83	218	240	15	....	....	....	75	8	....	....	634,500
Alaska-Mexican, G., Alaska	....	....	....	....	....	....	....	....	....	....	30	30,000
Alaska-Treadwell, G., Alaska (*a*)	....	....	....	....	....	....	....	450	300	375	375	1,900,000
Alice, S., G., Mont	150	125	75	....	25	25	95	75	....	....	....	975,000
Alma, G., Ida	....	....	....	....	....	15	....	....	....	....	....	60,000
Alturas, G., Ida	....	....	95	....	113	....	....	....	....	....	....	262,250
Amador Gold Mg. Co., Limited, G., Cal	....	....	....	....	....	....	31	....	....	....	....	31,250
American & Nettie, G., Colo	....	....	....	....	....	150	....	45	30	....	....	225,000
American Belle, S., C., Colo	....	....	....	....	....	....	....	50	....	....	....	50,000
American Coal, Md	....	....	....	....	....	....	....	90	90	90	90	360,000
American Dev. & Mg., Mont	....	....	....	....	....	....	....	....	....	....	52	52,154
American Turquoise, New M	....	....	....	....	....	....	....	....	....	60	....	60,000
Amy & Silversmith, Mont	....	....	205	43	....	....	....	....	....	....	....	247,530
Anaconda, G., Colo	....	....	....	....	....	....	....	....	13	....	....	12,500
Argyle, G., Colo	....	....	....	....	....	....	....	....	20	....	....	20,000
Aspen, S., Colo	....	....	....	....	80	280	200	100	100	100	40	900,000
Atlantic, C., Mich	40	20	40	40	120	80	100	40	....	....	....	700,000
Aurora, I., Mich	....	....	....	150	....	....	....	200	100	200	....	650,000
Badger, S., Can	....	....	....	....	....	....	38	....	....	....	....	37,500
Bald Butte, G., Mont	....	....	....	....	....	....	20	30	20	100	200	370,000
Ballarat Smuggler, G., Colo	....	....	....	....	....	....	....	6	....	....	....	6,000
Bangkok-Cora Belle, S., Colo	....	....	....	....	....	3	42	....	....	....	....	47,510
Bannister, S., Mont	....	....	....	....	....	....	24	72	6	....	....	102,000
Bassick, S., G., Colo	100	....	....	....	....	....	....	....	....	....	....	400,000
Bates-Hunter, G., Colo	....	....	....	....	....	....	....	68	....	....	....	67,500
Belden, F. E., M., New H	....	....	....	....	....	....	....	....	45	60	60	165,000
Bellevue, S., L., Ida	....	88	63	38	....	....	....	13	....	....	....	200,000
Best Friend, S., Colo	....	....	....	....	....	....	....	70	20	....	....	90,000
Big Bend, G., Cal	72	30	66	48	....	....	....	....	....	....	....	258,000
Bimetallic, S., G., Mont	....	....	....	....	....	....	290	840	200	190	....	1,630,000
Bodie Cons., G., Cal	350	50	....	....	....	....	....	....	....	....	75	1,677,572
Bonanza King, S., Cal	150	10	....	....	....	....	....	....	....	....	....	185,000
Boreel, S., Colo	....	....	....	....	....	....	....	....	....	60	23	105,000
Boston & Montana, C., S., Mont	....	30	180	....	400	500	625	500	....	....	275	2,325,000
Brooklyn Lead, L., S., Utah	....	....	20	25	....	....	....	....	....	....	....	127,000
Brotherton, I., Mich	....	....	....	....	....	....	....	....	40	80	....	120,000
Bull-Domingo, L., S., Colo	....	....	....	....	....	....	20	29	4	....	....	53,000
Bullion, Beck & Champion, Utah	....	....	....	....	....	....	....	....	....	....	425	425,000
Bulwer Cons., G., Cal	....	....	....	....	....	....	....	....	15	....	....	190,000
Bunker Hill & Sullivan, S., L., Ida	....	....	....	....	20	....	....	....	....	....	....	150,000
Buxton, So. Dak	....	....	....	5	....	....	....	....	20	....	....	25,000
Caledonia, G., Dak	....	20	20	....	16	80	56	....	56	....	....	192,000
California, G., Colo	32	....	....	....	....	....	20	....	....	....	....	116,500
Calliope, S., Colo	....	....	....	....	....	50	85	5	....	....	....	140,000
Calumet & Hecla, C., Mich	1300	1700	1000	1000	2000	2000	2000	2000	2000	2000	1500	41,350,000
Carbonate Hill, S., L., Colo	10	....	....	....	....	....	....	....	....	....	....	80,000
Carlisle, G., N. M. (*b*)	....	....	....	....	175	....	....	....	....	....	....	175,000
Catalpa, S., L., Colo	30	....	....	....	....	....	....	....	....	....	....	270,000
Centennial-Eureka, S., G., L., Utah	....	....	....	....	....	....	150	330	90	188	195	960,000
Central, C., Mich	40	30	40	40	70	40	20	20	....	....	....	1,970,000
Champion, G., Cal	....	....	....	....	....	....	27	43	41	41	41	191,800
Charleston, P., S. C	....	....	....	....	....	....	....	....	....	140	....	140,000
Chrysolite, S., L., Colo	50	....	....	....	....	....	....	....	....	....	....	1,650,000
Clay County, G., Colo	....	....	....	....	....	....	8	48	....	....	....	56,000
Cleopatra, G. S., So. Dak	....	....	....	....	....	....	....	....	....	450	....	450,000
Cœur d'Alêne Silver Lead Mg. Co., S., L., Ida	....	....	....	....	....	70	160	80	72	30	....	340,000
Colorado Central, S., Colo	....	60	111	83	83	55	....	14	55	28	....	502,661
Colorado Fuel Coal, L., Colo	....	....	....	....	....	178	189	252	67	67	....	752,700
Commonwealth, S., Nev	....	....	....	....	....	....	20	....	....	....	....	20,000
Confidence, S., Nev	....	....	....	....	175	25	....	....	....	....	....	277,680
Cons. Cal. & Va., S., G., Nev. (*c*)	....	....	65	1118	1118	756	162	216	....	....	108	3,790,000
Cons. New York, S., G., Nev	....	....	....	....	....	....	....	....	....	10	....	10,000
Consolidation Coal, Md	....	....	....	....	....	....	....	....	205	....	....	205,000
Contention, S., Ariz	63	....	....	....	....	....	....	....	50	....	....	2,637,500
Cook's Peak, S., L., Colo	....	....	....	....	....	....	....	55	60	....	....	119,532
Copper Bell, S., Mont	....	....	....	....	....	....	....	14	....	....	....	13,500
Copper Queen, C., S., Ariz	200	....	....	....	140	70	210	....	140	300	200	1,760,000
Coptis, S., Nev. (*d*)	....	....	....	....	....	10	5	60	15	10	....	100,000
Cortez, S., Nev	....	....	....	....	....	....	173	250	95	45	....	735,000
Cosmopolitan, S., Utah	25	....	....	....	....	....	....	....	....	....	....	75,000
Crescent, S., L., Utah	....	30	30	18	....	....	....	....	....	....	....	238,000
Daly, S., L., Utah	....	....	....	375	488	450	450	450	450	188	....	2,850,000
Deadwood-Terra, G., So. Dak. (*e*)	....	....	....	100	....	....	....	50	100	....	....	1,140,000
Deer Creek, S., G., Ida	....	....	....	....	10	10	....	....	....	....	....	20,000
De Lamar, S., G., Ida	....	....	....	....	....	....	....	150	272	450	400	1,272,000
Della S., Colo	....	....	....	....	....	....	....	....	....	....	50	50,000
Derbec, G., Cal	60	40	40	20	....	30	30	20	....	....	....	260,000
Dexter, S., Nev	....	....	....	....	....	....	....	50	80	115	....	245,000
Dunkin, S., L., Colo	10	....	....	30	100	40	....	....	....	....	....	390,000
Dunstone, G., S., L., Mont	....	....	....	....	6	....	....	....	....	....	....	6,000
Eclipse, L., S., Colo	....	....	....	20	....	....	....	....	....	....	....	20,000
Elkhorn, S., L., Mont	....	35	55	20	....	....	125	300	303	225	142	1,299,689
Elkton, Colo	....	....	....	....	....	....	....	....	....	....	60	60,000
Empire, G., Mont. (*f*)	....	....	....	71	....	....	....	....	....	....	....	70,500
Enterprise, S., G., Colo. (*m*)	....	....	....	....	....	....	....	250	450	150	....	850,000
Eureka Cons., S., L., Nev	....	....	....	50	88	....	38	50	13	....	....	5,112,500
Evening Star, S., L., Colo	....	....	....	....	13	25	....	....	....	....	....	1,437,500

DIVIDENDS PAID BY AMERICAN MINES—*Continued.*

Company.	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	Total.
Father de Smet, G., So. Dak	200	200	....	....	....	....	....	....	....	....	....	1,125,000
Franklin, C., Mich	80	40	80	40	160	80	80	80	160	120	80	1,240,000
Freeland, S., Colo	....	80	60	....	....	....	....	....	....	....	....	190,000
Garfield, S., G., Nev	....	....	13	13	25	....	....	....	....	....	....	85,000
Glengarry, S., G., Mont	....	....	....	....	....	....	....	10	....	....	....	10,000
Golconda, S., G., Ida	....	....	....	....	120	....	....	....	....	....	....	120,000
Golden Fleece, Colo	....	....	....	....	....	....	....	....	....	144	144	288,000
Golden Reward, G., So. Dak	....	....	....	....	20	....	....	....	60	60	....	125,000
Gold Rock, G., Colo	....	....	....	....	....	....	....	29	....	....	....	28,750
Granby, Z., Mo	....	....	....	....	....	20	....	....	....	....	....	20,000
Granite, S., L., Ida	....	....	....	....	8	20	....	....	....	....	....	28,400
Granite Mountain, S., G., Mont	....	580	1020	2000	1600	2400	2400	1400	520	....	....	12,120,000
Great Western, C., Cal	....	....	....	....	....	....	....	25	137	25	....	388,366
Hale & Norcross, S., G., Nev	....	....	....	....	224	....	....	....	....	....	....	1,822,000
Harquahala, Ariz	....	....	....	....	....	....	....	....	....	....	72	126,000
Hecla Cons., S., L., Mont	195	195	135	30	100	180	123	180	90	60	120	2,010,000
Helena & Frisco, S., Mont	....	....	....	....	....	....	79	190	20	....	15	315,000
Helena M. & R. Co., Mont	36	138	60	....	....	....	....	....	....	....	....	197,970
Helena & Victor, S., Mont	....	....	....	....	....	....	....	20	....	....	....	70,000
Holmes, S., Nev	....	....	50	....	....	....	....	....	25	....	....	75,000
Homestake, G., So. Dak	306	525	575	300	300	188	150	150	150	150	256	5,337,500
Honorine, S., Utah	13	50	25	38	....	....	....	....	....	....	....	125,000
Hope, S., Mont	....	36	....	25	50	....	....	....	100	175	75	593,250
Horn Silver, S., L., Utah	1200	....	....	....	....	50	200	200	200	230	150	5,037,500
Hubert, G., Colo	....	....	....	....	18	5	....	....	....	....	....	247,000
Idaho, G., Cal	226	270	271	140	357	178	29	93	42	105	....	5,489,000
Ideal, S., L., Colo	....	....	15	....	....	....	....	....	....	....	....	15,000
Illinois, S., New M	....	....	....	25	....	20	20	....	....	....	....	65,000
Iron Hill, So. Dak	....	....	112	44	....	....	....	....	....	....	....	156,250
Iron Mountain, S., Mont	....	....	....	....	....	....	50	25	....	30	50	295,000
Iron Silver, S., L., Colo	100	200	300	300	300	100	....	....	....	....	....	2,500,000
Ivanhoe, Colo	....	....	....	....	....	10	....	....	....	....	....	10,000
Jackson, G., S., Nev	10	15	20	....	....	5	....	5	....	....	....	78,000
Jay Gould, G., S., Mont	....	....	....	95	226	74	22	....	....	....	....	459,000
Jay Hawk, S., G., Mont. (*g*)	....	....	....	....	....	....	....	....	33	....	....	33,375
Jumbo, G., Colo	....	....	....	33	....	....	....	....	....	....	....	33,000
Kearsarge, C., Mich	....	....	....	....	....	....	80	....	....	....	....	80,000
Kennedy, G., Cal	....	....	....	....	....	....	....	360	500	480	540	1,612,000
Kentuck, S., G., Nev	21	....	3	....	....	....	....	....	....	....	....	1,350,000
Lady Franklin, New M	....	....	....	100	....	....	....	....	....	....	....	100,000
Lake Superior, I., Mich	....	....	....	....	....	....	....	....	400	....	....	400,000
Last Chance, S., Colo	....	....	....	....	....	....	....	....	650	....	....	650,000
Leadville, S., L., Colo	20	20	40	20	....	....	....	....	12	12	....	316,000
Lexington, G., Colo	....	....	....	....	....	....	....	....	36	....	....	36,000
Lexington, S., Mont. (*h*)	320	....	....	....	....	64	....	....	....	....	....	609,000
Little Chief, S., L., Colo	40	20	....	....	....	....	20	....	....	....	....	820,000
Little Rule, S., Colo	....	....	....	....	....	....	100	120	....	....	....	220,000
Maid of Erin, S., L., C., Colo. (*i*)	....	....	....	105	409	385	454	419	140	150	....	2,060,847
Mammoth, Utah	....	....	....	20	50	130	470	320	....	....	....	990,000
Manhattan, S., Nev	....	13	25	....	....	....	....	....	....	....	....	437,500
Martin White, S., Nev	....	....	50	....	....	....	....	....	....	....	....	140,000
Maryland Coal, Md	....	....	....	....	....	....	....	84	84	....	....	168,000
Mary Murphy, S., Colo	....	....	....	70	....	....	....	....	....	....	....	175,000
Maxfield, S., L., Utah	....	....	....	....	....	....	....	36	18	....	....	117,000
May Flower Gravel, G., Cal	....	....	....	....	....	....	....	75	25	120	120	340,000
May Mazeppa, S., L., Colo	....	....	....	....	....	....	70	110	....	....	....	180,000
Mercur, G., Utah	....	....	....	....	....	....	....	....	....	50	150	200,000
Metropolitan, I., Mich	....	....	....	....	....	350	250	350	....	....	....	1,637,500
Minas Prietas, S., Mex	....	....	....	....	....	....	50	....	....	....	....	50,000
Minnesota, I., Minn	....	....	....	....	....	....	....	840	840	495	....	2,745,000
Mollie Gibson, S., Colo	....	....	....	....	....	....	....	1000	1700	1230	100	4,030,000
Monitor, So. Dak	....	....	....	....	....	38	7	....	22	....	....	77,500
Mono, G., Cal	....	....	13	....	....	....	....	....	....	....	....	12,500
Montana Limited, G., S., Mont	....	123	617	719	413	206	178	83	....	....	....	2,685,287
Moose, Colo	....	....	....	....	....	....	....	....	....	....	108	108,000
Morning Star, S., L., Colo	25	25	125	75	....	....	....	50	....	....	....	925,000
Morning Star Drift, G., Cal	....	....	....	....	....	....	....	23	83	72	106	282,200
Moulton, S., Mont	80	150	90	60	....	....	....	....	30	....	20	430,000
Mount Diablo, S., Nev	....	30	....	....	40	40	20	30	....	30	....	240,000
Mount McClellan, S., Colo	....	....	....	....	....	....	....	13	....	....	....	12,540
Mount Pleasant, Cal	15	30	....	45	....	....	....	....	....	....	....	180,000
Mount Rosa, Colo	....	....	....	....	....	....	....	....	....	....	5	5,000
Napa, Q., Cal	....	....	....	....	....	30	40	40	70	70	50	660,000
Navajo, S., G., Nev	50	50	....	....	....	40	....	....	....	....	....	229,950
New Guston, S., Colo	....	....	....	....	100	188	170	440	124	....	....	1,210,000
New Hoover Hill, G., No. Carolina	....	37	....	....	....	....	....	....	....	....	....	37,200
Newton, Cal	....	....	....	....	....	....	....	10	....	....	....	10,000
North Banner Cons., G., Cal	....	....	....	....	....	....	....	20	....	....	....	20,000
North Belle Isle, S., G., Nev	....	....	....	....	200	....	....	....	....	....	....	230,000
North Commonwealth, S., G., Nev	....	....	....	....	....	....	....	25	....	....	....	25,000
North Star, G., Cal	....	....	....	....	150	100	....	50	50	100	....	450,000
Nugget, G., Colo	....	....	....	....	....	....	....	....	....	....	5	5,000
Omaha, G., Cal	....	....	....	....	....	....	13	....	7	43	43	106,100
Ontario, S., Utah	900	975	900	900	900	900	1650	900	750	....	....	13,175,000
Original, S., C., Mont	30	....	3	12	6	3	....	....	....	....	....	138,000
Oro, G., S., L., Colo	....	....	....	....	....	....	95	....	....	....	....	95,000
Oro Grande, G., Cal	175	15	....	....	....	....	....	....	....	....	....	188,860

DIVIDENDS PAID BY AMERICAN MINES—*Continued.*

Company.	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	Total.
Osceola, C., Mich	63	....	....	100	150	50	225	150	150	100	....	1,847,500
Pacific Coast Borax, B., Cal	....	....	....	....	....	....	....	180	180	63	....	422,500
Pamlico, Nev	....	....	....	....	21	12	....	....	12	....	....	189,080
Pandoro, Mont	....	....	....	....	....	....	....	3	3	....	....	6,000
Paradise Valley, S., Nev	50	....	....	10	....	....	....	....	....	....	....	160,000
Parrott, C., S., Mont	....	....	....	54	144	144	252	360	216	138	67	1,569,000
Peacock, New M	....	....	50	....	....	....	....	....	....	....	....	50,000
Petro, S., Utah	....	....	....	....	....	....	....	18	....	....	....	17,500
Pharmacist, G., Colo	....	....	....	....	....	....	....	....	36	48	....	84,000
Pittsburg, G., Nev	....	....	....	....	30	....	....	....	....	....	....	29,850
Pleasant Valley, C., Utah	....	....	....	....	....	....	....	....	....	20	....	593,056
Plumas Eureka, G., Cal	....	105	53	18	70	123	....	70	25	53	....	2,696,294
Plutus, S., Colo	....	....	20	....	....	....	....	....	....	....	....	20,000
Plymouth Cons., G., Cal	600	575	300	375	80	....	....	....	....	....	....	2,280,000
Poorman, G., Colo	....	....	....	....	25	15	85	....	....	....	....	125,000
Poorman, S., Ida. (*l*)	....	....	....	....	....	....	....	....	57	....	....	56,935
Portland Gold, G., Colo	....	....	....	....	....	....	....	....	....	....	67	67,290
Quicksilver, Q., Cal. (*j*)	13	....	118	129	283	193	257	118	....	....	....	2,475,082
Quincy, C., Mich	280	180	240	800	360	280	320	400	350	300	400	7,070,000
Red Cloud, S., L., Ida	....	....	....	....	....	....	20	80	70	10	....	180,000
Reed & National, S., G., Colo	....	....	....	....	....	....	45	....	....	....	....	45,000
Rescue, New M	....	....	....	....	....	....	....	....	12	....	....	12,000
Retriever, So. Dak	....	....	....	....	....	....	....	13	....	....	....	12,500
Rialto, G., Colo	....	....	....	....	....	....	....	32	18	....	....	50,250
Richmond Cons., S., L., Nev	68	68	135	68	....	....	....	34	....	14	....	4,386,780
Rico-Aspen, Colo	....	....	....	....	....	....	....	....	....	50	300	350,000
Robinson, S., Colo	....	....	10	....	....	....	....	....	....	....	....	585,000
Rocky Fork Coal, Mont	....	....	....	....	....	....	....	100	100	....	....	200,000
Rooks, G., Vt	21	30	....	....	....	....	....	....	....	....	....	61,000
Running Lode, Colo	....	....	....	....	....	....	5	25	6	1	....	27,000
Russell, G., Cal	....	....	....	30	....	....	....	....	....	....	....	30,000
Saint Joseph, L., Mo	40	66	184	90	....	....	....	....	....	....	....	1,974,000
Security, G., Colo	25	25	....	....	....	....	....	....	....	....	....	56,000
Sheridan, S., G., Colo	....	....	....	....	....	....	....	75	....	....	....	300,000
Sherwood, Z., Mo	....	....	....	3	....	....	....	....	....	....	....	3,000
Sierra Bella, S., New M	30	....	....	....	....	....	....	....	....	....	....	30,000
Sierra Buttes, G., Cal	15	31	76	76	15	....	....	25	36	31	....	1,584,933
Sierra Nevada, Ida	....	....	....	....	20	20	....	....	....	....	....	40,000
Silent Friend, S., L., Colo	....	....	....	....	....	....	....	60	....	....	....	60,000
Silver Cord, S., L., G., Colo	....	....	....	....	....	45	....	....	....	....	....	265,000
Silver King, S., Ariz	50	200	225	175	....	....	....	....	....	....	....	1,950,000
Silver Mining of Lake Valley, New M	....	....	....	....	25	25	180	80	....	....	....	310,000
Silverton, S., Colo	32	....	48	....	....	....	....	....	....	....	....	80,000
Small Hopes, S., Colo	800	888	775	600	....	25	25	....	38	25	....	3,225,000
Smuggler, Colo	....	....	....	....	....	....	....	....	....	....	650	790,000
Standard, G., Cal	75	....	....	20	50	....	....	10	40	20	40	3,751,160
Swansea, Utah	....	....	....	....	....	....	....	....	....	....	2	1,500
Syndicate, Cal	60	12	....	....	....	....	....	....	....	....	....	72,000
Tamarack, C., Mich	....	....	....	....	640	440	590	800	600	690	400	4,070,000
Teal & Poe, S. L., New M	....	....	....	....	....	....	....	9	....	....	....	9,000
Trinity River, Colo	....	....	....	....	....	....	....	....	....	15	....	15,000
Union, Colo	....	....	....	....	....	....	....	....	....	....	27	26,520
United Verde, C., S., Ariz	60	....	....	....	....	....	30	....	30	435	....	562,500
Utah, Utah	....	....	....	....	....	....	....	....	15	5	....	20,000
Valencia, M., New H	19	19	4	....	....	....	....	....	....	....	....	41,250
Victor, G., Colo	....	....	....	....	....	....	....	....	....	120	105	225,000
Viola Limited, S., L., Ida	....	....	38	38	94	....	....	....	....	....	....	337,500
Ward, Cons., S., Colo	....	....	....	....	....	20	....	....	....	....	....	20,000
Webb City, Z., Mo	....	....	....	....	....	4	....	....	....	....	....	4,400
Whale, Colo	....	....	....	....	....	....	....	5	....	....	....	5,000
Woodside, S., Utah	....	....	....	....	....	25	....	....	....	....	....	25,000
W. Y. O. D., G., Cal	....	....	....	....	....	....	....	6	36	24	36	84,000
Yankee Girl, S., Colo. (*k*)	....	....	300	187	....	....	125	260	....	....	....	1,665,000
Yosemite, S., Utah	....	....	....	....	....	....	....	....	5	....	....	5,000
Young America, G., Cal	....	....	165	....	10	....	....	....	....	....	....	175,000

(*G*) Gold; (*S*) Silver; (*L*) Lead; (*I*) Iron; (*C*) Copper; (*Q*) Quicksilver; (*B*) Borax; (*Z*) Zinc; (*M*) Mica.

(*a*) Formerly the Alaska Mining and Milling Company, reorganized in 1891 as the Alaska-Treadwell Gold-mining Company; the dividends credited for 1891 and 1892 are the payments of the latter company. The Alaska Mining and Milling Company paid $700,000 previously.

(*b*) Reconstructed into the Golden Leaf, Limited, of Montana.

(*c*) Previous to the consolidation in August, 1884, the California had paid $31,320,000 in dividends and the Consolidated Virginia $42,390,000.

(*d*) Formerly the Young America South Mining Company, reorganized as the Coptis in 1891.

(*e*) Previous to consolidation, the Deadwood paid $275,000 and the Terra $75,000.

(*f*) Reconstructed as the Golden Leaf, Limited.

(*g*) Jay Hawk and Lone Pine Consolidated Mining Company, Limited.

(*h*) Société Anonyme des Mines de Lexington.

(*i*) Maid of Erin Silver Mines, Limited, formerly Henriette and Maid Consolidated Mining Company. The dividends for 1887, 1888, 1889 and 1890 were paid by the old company, and those for 1891 and 1892 by the new company.

(*j*) Including dividends paid on preferred stock and common stock.

(*k*) Yankee Girl Silver Mines, Limited, formerly Yankee Girl Mining Company. The above statement includes the payments by both the old and new companies.

(*l*) Enterprise Mining Company, of Rico, Colo.; there is also an Enterprise Mining Company in Aspen and one in Leadville.

(*m*) Poorman Mines, Limited, operating the Poorman mine at Silver City, Idaho, which paid large dividends in 1865 and 1866.

Assessments Levied by Mining Companies.

The list given below includes the assessments levied for the nine years, 1887–1894, inclusive, so far as they can be ascertained. In the nature of affairs it is not possible to make such a list a complete one. In a few States the corporation law requires public notice of assessments, but in others this is not the case and notice is sent to stockholders only. Moreover, there are many closely held companies or associations in which the amount contributed by the owners is a matter not made public. The list of assessments for 1894 is not an unusually long one, and presents no features calling for special comment.

Name and Location of Company.	Levied in 1887.	Levied in 1888.	Levied in 1889.	Levied in 1890.	Levied in 1891.	Levied in 1892.	Levied in 1893.	Levied in 1894.	Total to Jan. 1, 1895.
Alliance, Utah	.....	.....	$30,000	.....	$40,000	.....	.....	.....	$150,000
Allouez, Mich	.....	$80,000	40,000	$40,000	40,000	.....	.....	.....	1,440,000
Alpha, Nev	$30,000	52,500	26,500	42,250	15,000	$36,750	$10,000	$6,000	226,000
Alta, Nev	100,000	108,000	.....	54,000	30,000	27,000	25,200	50,400	3,527,200
Anchor, Utah	70,000	105,000	15,000	.....	150,000	.....	90,000	.....	560,000
Andes, Nev	50,000	50,000	25,000	25,000	30,000	25,000	.....	25,000	230,000
Argenta, Nev	.....	.....	10,000	.....	.....	.....	.....	.....	335,000
Atlantic Con	10,000	.....	.....	.....	.....	.....	.....	.....	70,000
Baltimore, Nev	.....	75,000	50,000	20,000	.....	.....	.....	.....	145,000
Belcher, Nev	52,000	.....	104,000	104,000	104,000	78,000	.....	50,200	3,210,220
Belle Isle, Nev	35,000	.....	.....	15,000	.....	30,000	20,000	.....	230,271
Bellevue-Idaho, Idaho	31,250	18,750	12,500	16,037	.....	.....	.....	.....	104,787
Benton, Con., Nev	27,000	108,000	.....	.....	.....	.....	.....	.....	556,000
Best & Belcher, Nev	153,200	100,800	75,200	149,485	100,800	50,000	75,600	50,400	2,530,875
Bodie Con., Cal	100,000	100,000	75,000	50,000	.....	.....	40,000	15,000	730,000
Bodie Tunnel, Cal	25,000	25,000	.....	25,000	25,000	25,000	.....	.....	202,906
Brunswick Con., Cal	.....	.....	.....	.....	20,000	20,000	.....	8,000	48,000
Bullion, Nev	90,000	50,000	.....	25,000	50,000	100,000	25,000	30,000	2,970,000
Bulwer Con., Cal	20,000	20,000	50,000	.....	15,000	.....	10,000	10,000	165,000
Butte Queen, Cal	.....	.....	.....	.....	.....	4,000	.....	.....	6,000
Caledonia Silver, Nev	15,000	15,000	.....	.....	150,000	.....	.....	50,000	3,235,000
California, Cal	.....	.....	.....	.....	.....	6,000	.....	.....	12,000
Centennial Eureka, Utah	.....	30,000	.....	.....	.....	.....	.....	.....	30,000
Central North Star, Cal	.....	.....	.....	.....	.....	.....	10,000	.....	10,000
Challenge Con., Nev	.....	25,000	25,000	50,000	50,000	45,200	15,000	50,000	287,500
Chollar, Nev	112,000	112,000	112,000	.....	168,000	112,000	61,600	56,000	1,937,600
Cœur d'Alêne, Idaho	.....	25,000	.....	.....	.....	.....	.....	.....	25,000
Commonwealth, Nev	.....	50,000	.....	.....	.....	30,000	.....	.....	190,000
Comstock, Nev	15,000	.....	.....	.....	.....	.....	.....	.....	30,000
Concord, N. C	3,000	3,000	.....	.....	.....	.....	.....	.....	6,000
Concordia, Nev	.....	75,000	.....	.....	.....	.....	.....	.....	75,000
Confidence, Nev	12,480	.....	.....	18,720	18,720	49,920	.....	6,240	1,614,510
Con., Cal. & Va., Nev	.....	.....	.....	.....	.....	108,000	6,220	108,000	1,722,530
Con. Imperial, Nev	125,000	25,000	25,000	75,000	150,000	26,500	.....	.....	2,076,500
Con. New York, Nev	.....	.....	25,000	45,000	30,000	20,000	25,000	5,000	150,000
Con. Pacific, Nev	9,000	.....	15,000	6,000	.....	.....	.....	.....	198,000
Courier, Idaho	5,000	.....	.....	.....	.....	.....	.....	.....	10,000
Crocker, Ariz	15,000	25,000	20,000	25,000	20,000	5,000	5,000	.....	180,000
Crown Point, Nev	.....	150,000	100,000	.....	150,000	100,000	80,000	65,000	2,870,000
Del Monte, Nev	.....	25,000	20,000	20,000	29,050	20,000	.....	.....	120,000
Derbec Blue Gravel, Cal	.....	.....	.....	.....	.....	10,000	5,000	.....	15,000
Diana, Nev	.....	10,000	.....	.....	.....	8,000	.....	.....	83,000
East Best & Belcher, Nev	.....	.....	.....	25,000	45,000	20,000	.....	20,000	110,000
East Sierra Nevada, Nev	.....	.....	10,000	.....	10,000	.....	.....	5,000	25,000
Eureka Con., Nev	.....	.....	50,000	.....	.....	.....	.....	.....	550,000
Exchequer, Nev	20,000	40,000	25,000	50,000	25,000	45,000	15,000	10,000	710,000
Felice, Ariz	20,000	.....	.....	.....	.....	.....	.....	.....	20,000
Fisher, Ariz	20,000	.....	.....	.....	.....	.....	.....	.....	20,000
Flowery, Nev	.....	20,000	.....	.....	.....	.....	.....	.....	130,000
Found Treasure, Nev	6,000	18,000	12,500	45,000	.....	50,000	.....	.....	131,500
Gold Flat, Cal	.....	.....	.....	.....	.....	11,000	2,000	.....	13,000
Goodyear, Mont	.....	.....	.....	.....	.....	2,000	4,183	.....	17,183
Gould & Curry, Nev	162,000	140,400	91,800	60,400	64,800	76,400	80,200	32,400	4,720,800
Grand Prize, Nev	.....	25,000	120,000	25,000	.....	.....	.....	.....	785,000
Hale & Norcross, Nev	112,000	.....	.....	56,000	168,000	168,000	56,000	56,000	5,702,800
Hartery Con., Cal	.....	.....	.....	5,000	5,000	.....	.....	2,000	29,000
Hartshorn, So. Dak	.....	.....	.....	6,250	.....	.....	.....	.....	6,250
Hayward Group, So. Dak	.....	.....	.....	2,000	.....	.....	.....	.....	2,000
Head Centre & Tranq., Nev	.....	.....	.....	.....	.....	.....	.....	.....	22,824
Heath, Idaho	20,000	5,000	.....	.....	.....	.....	.....	.....	25,000
Hector, Cal	.....	.....	45,000	.....	.....	.....	.....	.....	45,000
Hidden Treasure, Cal	.....	.....	.....	.....	.....	.....	1,000	.....	1,000
Himalaya, Utah	1,800	900	.....	.....	1,800	1,800	.....	.....	10,800
Holmes, Nev	.....	.....	.....	25,000	.....	.....	.....	.....	345,000
Honorine, Utah	.....	.....	12,500	.....	12,500	.....	.....	.....	50,000
Hudson Bay, Cal	.....	.....	.....	.....	.....	.....	10,000	.....	10,000
Huron, Mich	120,000	.....	.....	.....	.....	.....	.....	.....	280,000
Independence, Nev	.....	.....	.....	.....	.....	5,000	.....	.....	345,000

ASSESSMENTS LEVIED BY MINING COMPANIES FROM 1887 TO 1895—*Continued.*

Name and Location of Company.	Levied in 1887.	Levied in 1888.	Levied in 1889.	Levied in 1890.	Levied in 1891.	Levied in 1892.	Levied in 1893.	Levied in 1894.	Total to Jan. 1, 1895.
Iron Hill, So. Dak.		36,250	15,000	20,625	15,000				169,375
Jack Rabbit, Cal.						15,000	13,000	5,000	118,000
Jackson, Nev.							10,000		247,500
John Duncan, Mich.			2,000						4,000
Julia Con., Nev.	16,500				11,000		5,000		1,479,000
Justice, Nev.	31,500	52,200			26,250	42,000	30,000	75,000	3,630,000
Kearsarge, Mich.	50,000								190,000
Kentuck Con., Nev.					36,750	31,500	10,500	26,250	103,750
Keystone, Nev.	10,000								240,000
Keyes, Nev.		95,500	30,000						125,000
Kingman Silver, Ariz.					5,000				5,000
King of the West, Idaho.	30,000	15,000							45,000
Kossuth, Nev.	10,800	10,800							433,000
Lady Washington, Nev.		27,000			21,400				128,400
La Plata, Nev.			3,000						3,000
Locomotive, Ariz.	75,000	25,000	10,000	5,000					115,000
Lone Star Con., Cal.						5,000			12,500
Manhattan, Nev.	200,000								250,000
Martin White, Nev.			25,000	50,000	50,000	50,000	25,000	25,000	1,350,000
Mayflower, Cal.	150,000	175,000	35,000						470,000
Mexican, Nev.	50,400	50,400	50,400	25,200	50,400	75,600	75,600	75,000	3,068,760
Michigan Gold, Mich.						10,000			40,000
Mikado, Mich.	9,200	6,000							15,200
Milwaukee, Mont.					2,500				12,500
Missoula Placers, Mont.	2,000								4,000
Modoc Chief, Idaho.						5,000			975,000
Mollie Gibson, Colo.						10,000			20,000
Montreal, Utah.						750			4,500
Mono, Cal.	100,000	25,000	62,500	12,500	12,500				772,500
Mount Terry, So. Dak.				750					750
Navajo, Nev.	50,000	30,000	10,000	15,000	15,251	20,000	20,000		555,521
Nevada Queen, Nev.	130,000		70,000		15,000	25,000	25,000		265,000
North Belle Isle, Nev.	100,000	50,000	100,000	20,000	50,000	20,000	38,075		513,075
North Bonanza, Nev.	15,000	15,000	10,000						240,000
N. Commonwealth, Nev.		30,000	30,000	25,000	25,000		10,000		120,000
North Comstock, Nev.	10,000								10,000
North Extension, Nev.	25,000								25,000
North Gould & Curry, Nev.			20,000		30,000	10,000	10,000	20,000	310,000
North Occidental, Nev.				6,000					13,000
North Peer, Ariz.		5,000	5,000	5,000					21,000
Occidental Con., Nev.	25,000	45,000	50,000	75,000	25,000	50,000	55,000	30,000	353,990
Ophir, Nev.	50,400	50,400	50,000	50,000	50,000	50,000	100,000	100,000	4,510,640
Original Keystone, Nev.						10,000			250,000
Overman, Nev.	28,800		57,600	28,800	79,340	126,720	60,000	34,560	4,130,960
Paradise Valley, Nev.		25,000							57,000
Pennsylvania Con., Cal.						2,750			36,050
Peer, Nev.			20,000	10,000	15,000	20,000	10,000	5,000	215,000
Peerless, Nev.	25,000	25,000	96,000	25,000	10,000	5,000	5,000	5,000	410,000
Phil Sheridan, Nev.	20,000	10,000	35,000						65,000
Pine Hill, Cal.							3,000	3,000	10,000
Potosi, Nev.	145,600	112,000	10,000	55,400	112,000	56,000	84,000	112,000	1,937,600
Queen Bee, So. Dak.				3,000					3,000
Rainbow, So. Dak.						1,250			4,250
Ropes, Mich.							20,000		20,000
Sampson, Utah.	25,000	100,000							288,257
San Francisco, Cal.	22,000								22,000
Savage, Nev.	168,000	112,000	112,000		112,000	122,000	112,000	100,800	894,600
Scorpion, Nev.	20,000	10,000	120,000	90,000		5,000		5,000	415,000
Seg. Belcher & Mides, Nev.		25,000	50,000	80,000	50,000	25,000	35,000	20,000	310,000
Seg. Iron Hill, Dak.	2,500								8,750
Sierra Nevada, Nev.	100,000	75,000	100,000	71,910	80,600	55,000	45,000	50,000	4,451,910
Silver Hill, Nev.			43,200	43,200	30,000	16,200	5,400	5,400	1,992,600
Silver King, Ariz.		50,000		30,000	60,000	25,000		100,000	265,000
Siskiyou Con., Cal.					8,000	7,000	9,000	16,000	40,000
Stanard, Cal.				50,000					100,000
St. Mary's Copper, Mich.							2,000		2,000
Summit, Cal.		5,000	2,500						120,000
Taylor Plumas, Cal.	4,000	6,000			10,000				20,000
Telegraph, Cal.						975			3,575
Teresa, Mex.						20,000	60,000		140,000
Tioga Con., Cal.		10,000							295,000
Triumph, Idaho.	10,000								20,000
Trojan, Nev.		10,000	10,000						370,000
Tuscarora, Nev.		5,000	10,000						15,000
Union, Utah.		1,000							7,000
Union Con., Nev.	75,000		75,000	50,000	80,000	50,000	45,000	35,000	2,485,000
Utah Con., Utah.							25,000	5,000	430,000
Wall Street, Mont.						900			1,500
Waterloo, Cal.							30,000		30,000
Weldon, Ariz.	20,000		10,000	10,000	10,000	5,000	10,000		65,000
Wood River, Idaho.					3,000				3,000
W. Y. O. D., Cal.					22,500				22,500
Yellow Jacket, Nev.			60,000			156,000	90,000	90,000	5,964,000

ELECTRICAL TRANSMISSION OF POWER IN MINING.

By Timothy W. Sprague.

The last few years have seen a great development of the application of electricity in mining and metallurgy. The electric current itself has not materially modified methods of mining ores and coal, but it has been found very useful as a power transmitter, and as such has caused modifications in apparatus of various kinds.

For certain underground uses electricity has been found very convenient and efficient as compared with compressed air. Each has its advantages in certain directions, but in new work electricity seems to be taking the lead, except in applications to reciprocating apparatus, such as percussion drills and single pick coal cutters, where the advantage still lies with air machines.

The costs of electrical installations for mining work have been largely reduced during the last few years, principally by improved methods of manufacture, simpler designs, close competition, and improvements in methods of construction for underground work. In many cases insulated wire is not now used underground; it was formerly a large item in first cost and in maintenance, but the use of bare wire is permitted by the better arrangement and stringing of wires, and the cheap, efficient insulators lately developed.

In general it is safe to say that an electrical plant can now be purchased of the best manufacturers at a cost 25% to 30% less than two years ago. The year 1895 will see the installation of more new plants than any year since the first plant was put in. Several large central stations for distributing power to two or more mines are being established, and the installation work in design and arrangement is being looked after as carefully as in a well engineered mill plant, where economy and efficiency are brought to their maximum limits.

Power transmission should be considered under two heads—first, long distance transmission, and second, distribution, as from a central power station, to various points in and around a mine for operating apparatus of various kinds.

The progress recently made in long distance transmission is almost entirely in the development of alternating current apparatus, because alternating currents of low potential can be transformed to high potential currents by a piece of apparatus called a "step-up transformer," which is comparatively cheap and has

no moving parts. The dynamo itself generates current at a voltage which is easily and safely handled. After transmission over the required distance the current is passed through a "step-down transformer," whereby the potential is reduced to whatever voltage is required for power or lighting work. As the cost of copper varies inversely as the square of the voltage, the advantage of high potentials for transmission is readily seen. Direct current cannot be transformed except by much more complicated apparatus. Another advantage of the alternating current apparatus is that no commutators are required. The commutator is one of the few wearing parts in a direct current machine.

The commercial efficiency of the alternating current belted generator of latest type varies from 90% in the sizes under 100 horse-power to 93% or 94% in larger machines. In direct-connected machines, where the friction of bearings is properly chargeable to the driving power, the commercial efficiencies equal the electrical efficiencies, namely 93% and 96% for small and large machines respectively. The efficiency of the step-up and step-down transformers is from 97% to 98% each. The loss in the line is usually fixed at from 5% for short distances, to 10% for longer transmissions, and can be regulated up to certain limits by the amount of copper used. The large unit motors will show the same efficiencies as the dynamos. Starting then with 1000 horse-power delivered to the generator, the total efficiency of the system would be 76% to 80% at the motor end of the transmission. The cost of such a plant, exclusive of water-power improvements, and water wheel, or initial steam plant, based on transmission 20 miles, transmission voltage being figured at 10,000, with 10% loss in the line, would be not far from $90 per horse-power delivered and erected. While this figure will serve as an illustration, it should not be taken as an exact basis for estimates, nor can comparisons be correctly made, on account of the effect of local conditions and the fact that each plant presents a problem in itself which must be correctly solved to obtain best results with minimum first cost.

Some generators are now wound for 5000 or 6000 volts, thus doing away with the step-up transformer where the distance is not excessive, and eliminating one source of loss from the system.

The most prominent electric transmission plant in this country, and probably in the world, is that taking power from Niagara Falls, and now being put in by the Cataract Construction Company.

The hydraulic work already done there will supply 100,000 horse-power available for driving generators. The first electric installation consists of three 5000 horse-power alternating current generators made by the Westinghouse Company, of a type and construction never before called for in electrical work. Prof. George Forbes was the engineer in charge of the work. The generators produce an alternating two-phase current at 2000 volts potential. When the point to which the power is to be transmitted is beyond the limits of the town the potential is to be raised by step-up transformers to any desired voltage, depending on the distance of transmission; but for Niagara and vicinity, the power is delivered to customers direct from the generators at 2000 volts pressure and transformed on the premises to whatever potential may be required.

As stated by Professor Forbes, the first work to be done with the current is for a metallurgical purpose. The Pittsburg Reduction Company has contracted for

1200 kilo-watts, or about 1600 horse-power of electrical energy, for its new works at Niagara, where it will be used in the reduction of aluminum. The contracts for the electrical apparatus and fittings, to furnish 7000 ampères at 160 volts continuous current, was placed with the General Electric Company, and new type apparatus has been designed for this work. Starting with 2000 volts the alternating current is brought 2600 ft. to the Pittsburg Company's works. Here it is transformed by the ordinary step-down transformer to 115 volts alternating. Rotary transformers are required to obtain direct current, in which form the energy is utilized in the reduction processes, at a pressure of 160 volts. The combined efficiency of the rotary and static transformers is guaranteed at 94½%, and the variation in voltage from full load to no load is limited to 5% as a maximum.

One of the latest transmission plants for mining purposes is that put in operation by the Compagnie du Boleo at Santa Rosalia, Mexico, where it operates extensive copper mines in which a large number of small steam engines were formerly used for hoisting, pumping, ventilating and other purposes, scattered over a wide territory. Fuel is expensive and no water-power in the immediate neighborhood could be utilized. A central power station has been installed by the General Electric Company, and three-phase alternating current is generated at 2500 volts pressure. This is fed directly into the lines at the same voltage, and 10% loss is allowed in the transmission. About 4½ miles from the generator a 20 horse-power motor drives a blower. At the same place a 15 horse-power motor is geared direct to a Lidgerwood hoist having a capacity to lift 1000 lbs. 200 ft. per minute. About 9½ miles in another direction a 20 horse-power motor operates a Knowles horizontal triplex pump. The plant is now being increased by the addition of three 10 horse-power Knowles triplex pumps and a 25 horse-power Lidgerwood hoist, all to be operated at distances of from four to ten miles from the central power station. The apparatus, including transformers, the motors being wound for a low voltage, is without any protection, rain being practically unknown.

Mr. Thomas Haight Leggett of Bodie, Cal., the author of a very interesting pamphlet on "Electric Power Transmission Plants and the Use of Electricity in Mining Operations," published in the "Twelfth Report of the State Minerologist of California, 1894," to which the writer is indebted for much valuable information, described in a paper read before the American Institute of Mining Engineers, February, 1894, the transmission plant of the Standard Consolidated Mining Company (of which he is manager), at Bodie, Mono County, California, from which the following condensed description is taken. The price of wood at Bodie was $10 per cord, so that for a 20-stamp mill, crushing and amalgamating 50 tons of ore per day, the monthly fuel bills often amounted to $2000. Green Creek, 12½ miles from Bodie, furnished 400 in. of water during the dry season, and by improving this power ample capacity was obtained to run a 160 horse-power Westinghouse alternating current generator wound for a potential of 3530 volts. This machine is driven by four 21-in Pelton water wheels, working under a pressure of 152 lbs. per sq. in., and making about 860 revolutions per minute. The common shaft of the wheels is connected by a rigid insulated coupling to the armature shaft. The difficulty of proper

regulation of the speed is entirely overcome by the use of the Pelton differential governor.

The length of the pole line is 67,760 ft. or 12.46 miles. Round tamarack poles are used, 21 ft. long, 6 in. in diameter at the top, set 4 ft. in the ground 100 ft. apart, with a 4½-ft. cross-arm ; 25-ft. poles are used through the town and along the line wherever there is danger of deep snowdrifts, a precaution well taken, as these poles have at times been nearly buried. The line crosses extremely rough country, which required a great deal of blasting for pole holes. Sixteen and one-half tons of bare copper wire, No. 1 B. & S. gauge, is in use, attached to standard double-petticoat deep-grooved glass insulators carried on Klein patented iron pins, the distance between the two wires being 3 ft. 8 in. Experience demonstrated that it was advisable to insulate the line wire at the insulators, which was done by using sheet rubber, Manson tape, asphalt paint, and an insulated copper wire for tie-wire. With this precaution the line has given no trouble whatever, carrying over 3000 volts without a leak, even during a severe ten hours' storm of first rain and then sleet and ice. Snow-storms have no effect whatever.

The power thus generated and transmitted is used through a 120 horse-power synchronous motor, which drives the stamp mill, containing twenty 750-lb. stamps, four 6-ft. Frue vanners, eight continuous process amalgamating pans, two of which are constantly grinding, three settlers, one agitator, one pan and settler devoted to the amalgamation of concentrates, a bucket elevator, a worm gear hoist, and a rock crusher. This motor has started all twenty stamps while resting upon the cams, though this, of course, is not the ordinary way of taking up a load. The motor is always brought into synchronism with the generator by means of an auxiliary Tesla motor before any load is thrown upon it. It is then connected with the main driving shaft making 860 revolutions per minute by a friction clutch.

Since the first installation a 15 horse-power 500 volt direct-current generator has been added, belted from the main motor, and furnishes current for a ten-horse motor which hauls the tailings up an incline 1400 ft. away from the mill. The balance of the power of this generator is used for lighting the leaching plant and running the pumps. The entire mill and offices of the company are lighted by incandescent lamps, current being taken from the main transmission line and converted to proper voltage.

Various tests made upon this plant show that the proportion of the water-power obtained at motor pulley runs from 77.2% to 79.2%, the loss in the line running from 8.9% to 8%. The plant has made several unbroken day and night runs of long duration, one run of 13 days and another of 20 days being recorded. The only trouble experienced with the plant has been from lightning. This has been overcome, to a very large extent, by building lightning-arrester houses at each end of the line close to the power-house and motor-room, these being fitted up with banks of spark-gap-arresters and choke-coils of the Wurts pattern.

The entire cost of the original plant was under $38,000, while its operation during one month alone effected a saving of $2100, equivalent to $1.46 per ton of ore crushed, and reducing the total milling cost to $2.32 per ton. The plant

is at the present time operating smoothly and demonstrating successfully the effectiveness of the alternating synchronous system for such work, although installed at a time when this class of work had not received the amount of study which has since been devoted to it. The daily saving over the use of steam on a twelve-hour run is from $35 to $40.

The Gold King mill of the San Miguel Consolidated Gold Mining Company, near Telluride, Colo., is operated electrically, power being transmitted nearly three miles from a water-power. Here again Westinghouse alternating apparatus of the synchronous type is used. The generator is of 125 horse-power capacity, driven by a Pelton wheel operating under a head of 320 ft. A bare wire conveys current to the mill where a synchronous motor of 100 horse-power runs the stamps, crushers, etc.

The success of this plant led to the installation of a 750 horse-power generator in the same power station, from which current is taken for operating a mill 10 miles away, and for lighting and power work at Telluride, 8 miles away.

From the fact that lightning is one of the most serious drawbacks to the satisfactory working of transmission plants in the Western States much credit should be given to Mr. Alexander J. Wurts, of the Westinghouse Electric and Manufacturing Company, who has made the subject of protecting these lines from lightning a study, having spent a large amount of time in Colorado with this particular object in view, and has succeeded in developing a system of protection which has proved highly efficient under practical tests.*

Among other alternating transmission plants illustrating the latest developments and improvements is one at Silverton, Colo., where a 200 horse-power three-phase alternating generator wound for 2500 volts furnishes current for a 125 horse-power motor running the mill, a 100 horse-power motor driving an air compressor and a 75 horse-power electric hoist. A second generator of equal size is being added and further motor applications will be made. The distance of transmission is from three to five miles.

The General Electric Company has also installed a three-phase alternating plant at Park City, Utah, where the Ontario drain tunnel furnishes a water power which is transmitted 5½ miles by electricity at a pressure of 2500 volts and there utilized by means of two 15 and one 25 horse-power motors; a 12% drop in the line is here allowed.

The plant of the Montmorenci Electric Power Company, of Quebec, P. Q., put in by the Stanley Electric Manufacturing Company, and that of the United Electric Light Company of Springfield, Mass., put in by the same company, are excellent examples of the commercial success of long distance electrical transmission on the two-phase alternating system, though not in the line of mining work. In the former, the transmission is 8 miles from the Montmorenci Falls into Quebec, where the current is used for every variety of lighting and power work.

The Springfield company utilizes a water power at Indian Orchard, 6½ miles from the city, and brings the current to its distributing station at a pressure of 3600 volts.

The Compagnie Anonima de Transmission Electrica de Potencia, of Mexico

* See A. J. Wurts' paper read before American Institute of Electrical Engineers, Philadelphia, May 15, 1894.

City, Mexico, has been organized to install a plant for distribution of 2000 electric horse-power in the vicinity of Pachuca over a distance of 23 miles for mining purposes, utilizing the water falls of 700 ft. head at Regla for this purpose. Several large motors for mills will be installed, wound for high voltage, and a large number of stamps, hoists, crushers, pumps and ventilators will be run by lower voltage motors. The initial voltage here will be 700 transformed to 10,000 for line transmission.

Before passing from the subject of long-distance electrical transmission of power, a curious fact should be noted. This is that with a moderate loss allowed in the line, a low load may increase the total efficiency of the system. This will be seen to be true if the gain in the line (that is, less loss due to light load) more than balances the loss in machine efficiency due to same cause. This is a condition which does not hold in any other system of power transmission.

For distribution over short distances the use of high potentials is of course unnecessary, and for this work direct current apparatus of a voltage of 250 or 500 is ordinarily employed. The simplicity of alternating current apparatus, absence of commutators, with other advantages, and the progress constantly being made in the elimination of defects which have heretofore existed, may make its use advisable in nearly all cases, even where the distribution is over short distances. Where there is a probability of numerous extensions of work from one central power-house, the purchaser will do well to carefully investigate what the manufacturing companies can offer him in the line of alternating current apparatus.

In considering electrical energy as a distributor of power in mining work, the principal applications are: 1. Haulage. 2. Hoisting. 3. Pumping. 4. Ventilating. 5. Lighting. 6. Drilling. 7. Coal cutting. 8. Miscellaneous.

Haulage was one of the first uses to which electricity was put under ground, and long before electric street cars were in operation, except in one or two cities, coal was being hauled by an electric trolley locomotive in two of the anthracite mines of Pennsylvania. Where the bulk of material to be handled is small, nothing is gained, as a rule, by the introduction of machinery for transportation. On this account electricity has found its widest field in coal and iron mines. It is in haulage, perhaps, that electricity shows its most decided advantage. The electric locomotive has been developed to a point where it is now a perfectly reliable machine, and several companies using them have not a single mule or horse at work. In general it may be stated that with a fairly even (not hilly) haul of 1500 ft. or over, continuous or extended grades, not over 6% to 7% against loads, and a tonnage requiring from six mules and three drivers upward for its handling, the introduction of an electric haulage system will show a substantial saving over mule haulage, the amount depending of course upon a variety of local conditions. It is impossible to give this in figures applying generally. The additional saving in yardage in low coal seams will sometimes itself pay for the entire installation in a short period of time. A plant complete, including power-house, boilers, engine, generator, line material, including track bands, and locomotive capable of handling 1200 to 1400 tons per day run of mines coal, over a track practically level and able to haul 2500 ft. one way, can be installed for about $6000. Such a plant could be operated by two men and a boy, one man looking after the power station, the other operating the locomotive,

and the boy doing the coupling. Where power is used for other purposes in addition to haulage, the time of the man in charge of station would not of course be chargeable entirely to haulage.

Allowing $750 per year or $2.50 per day for interest, depreciation, supplies and repairs, and reckoning on a basis of 300 days in the year, the labor item being fixed at $4.75 per day for the three laborers mentioned, and fuel and water cost neglected, the cost of haulage would be a little over 0.6c. per ton. The effects of grades and local conditions generally must be figured out for each particular case, but the figures quoted give a fair basis for comparison. They suppose a case where trips are made up by mules or otherwise at a main gathering point and hauled by the locomotive 2500 ft. to the tipple or shaft, empties being taken back and delivered in a trip at the same point for distribution to rooms again by other means. That is, the electric locomotive is constantly employed on the main haul and does no collecting from rooms or side entries, or distributing to the same. This has been the usual mode of operation, but at the present time many plants are equipped with electric haulage so arranged that mules are entirely dispensed with, the locomotives collecting and distributing single cars, as well as hauling the full trips in and out. It is impossible to give figures for this work in any general way. The local conditions must be known in each particular case, and even then an important factor is the intelligence and good judgment of the bank boss and locomotive driver in the making up and distributing of their trips.

A point which must not be overlooked in comparisons betwen mule and electric haulage, particularly in times of frequent shut-downs, strikes, etc., is the fact that as soon as work ceases, expense on the electric haulage ceases, whereas mules are nearly as expensive to keep when idle as when earning something.

The flexibility of the electric system is another point in its favor, and recent developments in overhead construction work have made the extension of an electric haul an easy matter, so that in many cases the trolley wire may profitably be strung in side entries where the work is to be only temporary.

The earlier types of mine locomotives were equipped with a single motor which connected with one or both of the main axles through a series of gears and pinions. While this type has given and still gives satisfaction where in use, the more general type at the present time is a two-motor machine, each motor being independent of the other and geared directly to one axle. A very sensible basis for rating locomotives has been generally adopted by their manufacturers, namely, the draw-bar pull exerted, leaving the speed at which they are operated to determine their horse-power rating.

As an illustration of an electric haulage and what it is doing at the Forest City mines of the Hillside Coal and Iron Company of Scranton, Penn., the following information, prepared by Mr. Rufus Foster of Scranton, is of interest. The Hillside Coal and Iron Company was one of the first to adopt electric haulage. The company put in a locomotive at its Erie colliery in 1889, and its success led to the introduction of the same system at Forest City No. 2 colliery. The original plant has been added to several times until at present it consists of three 85 horse-power General Electric generators, operated by a 16 by 18 in. Armington & Simms engine and an 18 by 24 in. Payne engine. The power-

house is a frame structure 45 by 50 ft. in size, and located 150 ft. east of the shaft. The current is carried down the shaft on two lines of No. 0000 copper wire, one line being armored cable and supplying the slope workings through a connection halfway down the shaft, and the other lead covered and running to the foot of the shaft. The feed-wires leading from these conductors run through the workings, sometimes parallel with the trolley wires, and sometimes through short cuts in old workings, thereby saving distance. Three locomotives are in operation, two in the shaft workings and one in the slope. One of the locomotives in the shaft workings and the one in the slope are of 4500 lbs. draw-bar pull each. Their weight is about 11 tons each and they run on a 45-lb. T rail, the mine track being 36 in. gauge. The locomotives stand 40 in. high from the top of the rail, being 2 in. lower than the mine cars. The cars weigh 1900 lbs. empty, and 6400 lbs. loaded. Their wheel base is 24 in., and the wheels run loose on the axles. The usual trip for each of the large locomotives is 15 loaded cars; if necessary, however, trips of 30 cars can be handled. The maximum grade against load is 3.45%, continuing nearly 400 ft. The general speed of these machines is eight miles per hour.

The smaller locomotive used in the shaft workings gathers trips for the larger machine and is capable of exerting a draw-bar pull of 1500 lbs. It weighs 9000 lbs. and stands 34 in. high from the top of rail.

The detailed reports of the work done by the locomotives in 1892 and 1893 show that in the former year it was possible to increase the output per day in the shaft workings 13.9% by means of electric haulage, while the cost of haulage per ton was reduced from 2.49c. by mules to 1.82c. by locomotives. The distance run per day averaged 31.4 miles. In 1893 the increased output of the shaft over that when mules were used was 24.5%, and the cost of haulage per ton was reduced to 1.42c., showing a reduction in cost of haulage as compared with mules of 43%. The distance run by the locomotives in 1893 averaged 36 miles per day. In the slope workings an increase in output per day of about 50%, and a decrease in cost of haulage per ton of 25%, followed the introduction of the locomotive. The showing here is less favorable because the locomotive was worked only part of the time. For 1894 the cost of haulage in the shaft workings rose to 1.49c. per ton, on account of a slight decrease in output. The slope workings for the same period showed a reduction in cost of haulage per ton to 2.34c. from 3.33c. in 1893. The cost of mule haulage here was 4.44c. per ton, making the saving 47.5% of the cost of mule haulage.

In addition to the haulage work the electric current lights the bottoms of the shaft and slope and each switch and turnout along the entire haulage way. Power is also furnished for a small 4 by 4 in. Gould's triplex pump, which, with its motor, is mounted on a portable truck and carried around wherever needed. One or two single boring electric drills have also been installed, operated from the same power circuit. The entire cost of the operation of the plant is charged to the haulage account. Included in the cost is the service of a practical electrician who supervises the entire plant.

The haulage and pumping plant of the Mt. Lookout Coal Company, at Wyoming, Penn., near Scranton, is another interesting example of electric application in anthracite work, particularly from the fact that a higher voltage

is employed than is usual in underground work, namely 500 volts. The plant consists of a 135 horse-power General Electric generator for power, and a 25 horse-power lighting dynamo, both operated by a McEwen high-speed automatic engine. The power current is used in operating two locomotives, one of 2500 lbs. and the other of 1500 lbs. draw-bar pull, and a 25 horse-power Knowles duplex pump, which replaces an air pump.

The Berwind-White Coal Mining Company has adopted electric haulage at its Eureka No. 22 mine and has entirely dispensed with mules. The success of the plant has decided the company to extend the system elsewhere and Eureka No. 26 is now being equipped for electric haulage.

In other branches of mining electric haulage has made progress. The Pittsburg & Lake Angeline Mining Company and the Cleveland Iron Mining Company, both of Ishpeming, Mich., have been hauling ore for over two years by electric locomotives. The Anaconda Copper Company of Montana is just introducing electricity for haulage of ore, and the Wythe Lead and Zinc Company, of Virginia, has utilized a water-power and electrical transmission for its ore transportation for three years past.

The Jeffrey Manufacturing Company of Columbus, Ohio, has installed, for haulage and coal cutting, 97 separate plants, scattered over the entire world.

These few instances of what has been done are given simply as examples, but in no way cover the field of this class of application.

Coal Cutting work is confined to bituminous operations. Several types of electric coal cutters are in use, most of them having their duplicates in machines operated by compressed air. In single-blow pick machines, the type operated by air seems to have the field practically to itself, the electric machines failing to give satisfaction, owing largely to the cost of maintenance and repairs. The difficulties are mostly mechanical and may be overcome in the future. The solenoid type of coal-cutting machine, as well as the solenoid rock drill, are but little used, the extreme weight necessary to obtain a powerful blow being too great a handicap to be carried.

The subject of coal cutting has attracted a great many inventors and mechanics, so that almost every mining district has one or more coal cutters of a new type on trial. The machine which is to-day most largely used in new installations is an endless chain machine of the type originally called the Lechner, from the name of its inventor. At the present time this type of machine is being manufactured by several different companies and under several different names. In its most popular form it is operated by an electric motor and undercuts the coal to any depth required up to 6 or 7 ft. by means of cutting chisels carried on an endless chain. The height of the undercut is usually from 3½ in. to 5 in.; the width 3½ ft. The latest machines make a 6-ft. cut and withdraw in from 5 to 6 minutes. In figuring the tonnage which can be depended on per machine, the thickness of the vein is of course the important factor, and next to it is the time taken in moving the undercutter along the face after each cut and withdrawal, and also the moving of the machine from room to room. The last two factors depend on the personality of the machine operators, the way the work is planned and laid out by the bank boss and other details of mine management making any close guarantees on this subject impossible. The sooner this fact is

recognized by operators the better will be the results of coal-cutting installations both to operators and manufacturers.

In planning a coal-cutting installation the amount of power required per cutter depends largely on the number of machines to be operated from one central station. With but one or two machines, a wide margin should be allowed over the usual rating given by manufacturers, as experience has proven at certain times the amount consumed by a single machine far exceeds its usual limit. If several machines are to be operated from one central station advantage may be taken of the fact that at no time is it probable that more than two machines will be consuming this maximum power simultaneously. In general, the larger the plant and greater the number of applications of electric power the less may be the allowance of power per machine in planning the generator station.

The most notable installation of coal-cutting apparatus recently undertaken is that of the Essen Coal Company, for its No. 2 and No. 3 mines at Hazeltine, near Pittsburg, Penn. The horse-power of the electric plant is 600. The current will be used to operate 16 chain coal cutters, and in addition two 80 horse-power locomotives will be used. The entire plant is being put in by the Link Belt Machinery Company of Chicago, which has recently gone into the electrical business, having absorbed the Independent Electric Company.

The Crozer Coal and Coke Company of Elkhorn, W. Va., is installing an interesting coal-cutting plant of Jeffrey chain machines operating on a 500-volt circuit, which is unusual in coal-cutting work. There will be 10 coal cutters and an electric locomotive.

The operators of West Virginia are showing a marked activity in electrical work. In addition to the plant above mentioned, the Winifrede Coal Company, one of the largest companies operating along the Kanawha River in West Virginia, is putting in a coal-cutting and haulage plant of 300 horse-power. The Link Belt Company's chain cutters will be used, also one or more locomotives.

The Pulaski Iron Company of Eckman, W. Va., is putting in four Jeffrey chain cutters and a large locomotive, and the Southwest Virginia Improvement Company, at Pocahontas, Va., is using eight of these machines and several boring drills.

A plant which is unique from the fact of employing an alternating current in coal-cutting work, is located in the First Pool mines at Benola on the Monongahela River in Pennsylvania. It was installed several years ago by the Westinghouse Company, a 100 horse-power alternating generator furnishing current. The distance from generator to location of undercutters is nearly three miles. The machines are of the Michelis pattern operated by Tesla alternating motors.

Ohio, Indiana and Kentucky are dotted with electric mining plants for both undercutting and haulage.

It is impossible to give in the space at command anything like a complete list of new electric plants for coal cutting or other purposes, nor is it necessary in order to demonstrate their wide adoption and adaptability to all classes of work.

The usual price of coal-cutting machines varies from $1300 to $1500 each, and they consume ordinarily from 20 to 25 horse-power each.

Pumping.—In pumping, the installation of electric apparatus has been rather restricted, owing to the fact that the type of pump in use in mining work is radically different from that required for operation by motors, and the installation of electricity for this work means, except in new plants, putting in new pumps entire and discarding therefor expensive apparatus. It requires on this account a remarkably good showing in operating expense to overcome this item of first cost, where steam pumps are to be replaced. In new work, however, the situation is entirely changed. Here the first cost is high compared with steam pumps, but not prohibitive.

One form of electric pump which has met with great favor from mining men, is that mounted on a portable truck so that it can be moved about readily as occasion requires. Such a pump has been in operation a year or more in the William A. colliery of the Connell Coal Company, near Scranton, Penn. It is a 6½ by 8 in. horizontal pump of Gould's manufacture and operated by a 15 horse-power waterproof motor.

Another notable pumping plant is that of the Delaware, Lackawanna & Western Railroad Company's Woodward shaft, also near Scranton. A 35 horse-power generator furnishes current for a 4 by 6 in. vertical Knowles pump which is operated by a 3 horse-power motor and handles 50 gals. per minute against 60 ft. head, and also a 6½ by 8 in. horizontal portable pump mounted on a truck made to fit mine track gauge and operated by a 15 horse-power waterproof motor. The larger pump handles 150 gals. per minute against 350 ft. head. The excess generator capacity is utilized in lights, etc.

A plant just installed at Scott Haven, Penn., by the Youghiogheny River Coal Company, illustrates the use of electricity in power distribution in an interesting manner. A power station has been located most advantageously for supplying power to four separate mines operated by the company—No. 1 at Scott Haven, No. 4 and Southwest at Buena Vista, and Pacific at Douglass Station. Three generators of 135 horse-power each have been put in, and will distribute current at 500 volts pressure. The applications of power will be as follows: At the Pacific mine, 16,500 ft. from the power-house, a 50 horse-power electric locomotive, a 10 horse-power pump and a 30 horse-power ventilating fan; at Buena Vista, at No. 4 mine, a 10 horse-power pump, and at Southwest mine, a 7½ horse-power pump. To each of these mines the distance of transmission is 7500 ft. At No. 1 mine in Scott Haven, 7800 ft. from the power-house, a 50 horse-power locomotive, a 10 horse-power pump and a 25 horse-power fan will be installed. At this mine there are also five Jeffrey chain coal-cutters. Two other mines in the vicinity will be supplied with power in the near future. An interesting point in this installation is the conveying of the current under the Youghiogheny River by means of large submarine cables, most of the work being on the side of the river opposite the power station. Altogether this plant furnishes a very good example of the diversified problems met and successfully solved in electrical mining applications.

Mexico furnishes a number of interesting examples of pumping in connection with other electric power work, most of them being of very recent date.

Two pumping installations which have a historic interest are those of the Poorman mine of the Cœur d'Alêne Silver and Lead Mining Company, Burke,

Idaho, where a 9½ by 12 in. double-acting horizontal duplex pump handles 500 gals. per minute, against 500 ft. head, and at the Virginius Mining Company's plant at Ouray, Colo., where a 5 by 12 in. double-acting duplex pump raises 250 gals. per minute 800 ft. Both these pumps are of the outside-packed plunger type of Knowles' manufacture and have been in use several years. The first pump is run by a 1200-volt direct current motor. Power is used for other purposes, also, and the saving effected by the system is estimated at $100 per day. At the Virginius plant 300 horse-power is used, running a blower, stamp mill and concentrating mill in addition to the pumping. Water furnishes the initial power, and with coal at $18 per ton the saving is material.

The Calumet & Hecla Mining Company has an important electric pumping plant which has also been in operation for some time; it consists of eight double-acting triplex pumps, each having a capacity of 500 gals. per minute against 575 ft. head.

Hoisting.—In hoisting, the economy, adaptability and convenience of electric operation have led to a wide adoption of electricity. It is a comparatively simple matter to adapt the ordinary steam hoist to operate by electric power. The use of electric power removes in many cases a serious problem of how to locate the hoist where power is available, and at the same time where it is most needed. A compromise is not necessary, and electric hoists are now in operation where no other method of operation would be feasible, if even possible.

The two-motor hoist recently made by the Jeffrey Company for the Priceburg mine, near Scranton, is one of the latest productions in this line, and the two-motor feature is novel. The hoist has a capacity of about 80 horse-power, hoist rating, with a drum 7 ft. in diameter, and a 7 ft. face. The two-motors give it practically a twin drive, and are entirely interchangeable with each other and also with the motors on an electric locomotive which forms a part of the plant, a very important feature as affecting the amount of investment advisable in spare parts. The hoist also possesses advantages in efficiency of speed control due to double-motor drive. It is used at the upper end of a slope for hauling cars out of the butt entries and lowering them to the level track where they are made up in trips for the locomotive haul.

Mr. James T. Gardiner, consulting engineer for the Pleasant Valley Coal Company, of Castle Gate, Utah, was one of the first engineers in the country to see the value of electrical applications underground, and planned an interesting hoisting plant for that mine, which has been gradually increased until there are now in operation along the haulage way five 70 horse-power electric hoists of Lidgerwood and General Electric manufacture, all operated from an outside central station. The dip of the coal requires frequent inclines in favor of the loaded trips. At the top of each incline is an electric hoist with a powerful brake arrangement, designed by Mr. Gardiner, and these hoists lower the loaded trips from one level to another and hoist the empties back again, mules being used on the short intervening hauls. As the work progresses additional hoists can be added with but a small outlay. A single rope is used with each hoist.

In and around Aspen, Colo., a large number of electric hoists are in use. Their introduction dates back five years. The Roaring Fork Electric Light and Power Company furnishes power for mills, hoists, pumps and tramways within a

circuit of five miles. The Aspen Mining and Smelting Company uses 100 horse-power in electric hoists. The People's Electric Light and Power Company distributes several hundred horse-power for mills and mines. All these plants are operated by water-power.

A very cheap but at the same time efficient and satisfactory hoist is in use by the Paymaster Mining Company at Ogilby, Cal., where the dryness of the mine allows the use of a belted type of hoist, the motor being entirely separate from the hoisting drum and the driving connection made by belt.

Portable electric hoists are also in use to some extent in small sizes, and like portable pumps offer advantages for temporary work.

Drills.—Three distinct types of electric drills are in use in mining and quarrying operations. The first of these and the type most used is the rotary auger drill for slate or coal work. The problem here was to produce a strong piece of apparatus to stand rough usage and at the same time light enough to be readily handled, and capable of drilling at a rate which would make its use economical in comparison with hand drilling.

The latest boring drill weighs, exclusive of mounting column, about 100 lbs. The column adds 50 to 60 lbs., according to height of seam for which designed, and is adjustable to different heights within certain limits. The rate of boring is 6 ft. per minute in coal, and about 4 ft. per minute in hard slate. Drilling in hard rock has also been tried with success. Several types are manufactured and they require about 2 horse-power each to drive them. They cost complete with mounting column about $250, and are wound for 220 or 500 volts.

In percussion drilling, the problem presented is one which has not yet been commercially surmounted. The reciprocating motion with a varying length of stroke required, called for entirely new designs in motor work. The solenoid principle accomplished what was desired, but in order to obtain proper force for the blow the drill was made too heavy for ready handling underground. Another point against its general adoption is the complicated generator required to give the pulsating current needed and the necessity for wiring to each drill, entirely separate from other circuits in use.

The third type of electric drill is the diamond prospecting drill. The Sullivan Machinery Company installed several drills operated by electricity in the vicinity of Aspen, Colo., over four years ago, and they have done excellent service. The drill is a modified form of the prospecting drill operated by steam or air. Its advantages over steam or air operation lie in the ease and efficiency of transmission and the readiness with which it can be moved from place to place. At the Smuggler mine, at Aspen, one of these drills has drilled 400 ft. of hole in a week, making 30 to 40 ft. per shift of eight hours.

Another form of prospecting drill made by the General Electric Company is described by Mr. J. N. Bulkley, chief engineer of the mining department of the Pennsylvania General Electric Company, as follows: "For prospect work, a diamond drill, specially adapted for use with a motor, has been devised. The machine consists of a vertical drilling head, driven by an electric motor and having combined with it, upon the same base plate, a winding drum and winch head. The drill is fitted with a hydraulic feed, the drilling head being mounted on plunger rods working in pistons, and a separate system of pipes is provided, so that water, under pressure, may be admitted above or below the piston, as

desired. By means of a pressure gauge, the exact conditions under which the drill is working can be seen at a glance, and if, after being set to cut at a known rate, the drill should encounter a hard stratum, the fact will be made apparent by the change of pressure shown on the gauge. The regulating valve can then be altered to suit the new conditions. This drill may be operated to a depth of 600 or 800 ft. or more."

Ventilation.—A number of applications have already been noted. The location of the electrically driven fan, can be fixed without giving the question of its accessibility much thought. The motor may be either direct connected to the fan, that is, with one common shaft for armature and fan, or it may be geared to the fan shaft, or again, a belt connection may be used. Owing to the importance of entire reliability in ventilating work some automatic arrangement for giving an alarm at the power station or other point should anything abnormal occur, ought to be provided, particularly if a fan is in an out-of-the-way place. In a mine equipped with electric power advantage is taken of the ease of operating auxiliary electric fans, to improve ventilation.

Lighting.—The advantage of mine lighting, that is, of a sufficient illumination at the foot of shafts and slopes and at switching points, was not fully appreciated until electric lights had been tried for these purposes.

Incandescent lamps are best suited to inside work and are arranged in series according to the voltage employed. For above ground and outside illumination arc lights are employed, run from the power circuit or from a separate dynamo. Their use around mills, concentrating works, coal breakers and tipples, increases the working time in winter, and is almost essential for all night runs beside lessening the fire risk, as shown by insurance statistics.

The portable electric lamp is sure to prove of great use in the future, although at the present time it is not widely known, and no device has yet been made practically serviceable in connection with such a lamp for detecting gases.

Miscellaneous Applications.—Under this heading many examples may be cited. Some have already been mentioned in connection with plants illustrating other applications. The running of air compressors for operating percussion drills or coal cutters is a type of application which has already been made to some extent and will doubtless find further favor. This combination allows the air transmission pipe-line to be shut.

The telephone will undoubtedly find a large field in underground work. The introduction of all kinds of powerful electric machinery, situated hundreds or thousands of feet away from its source of power, the central station outside, makes it not only advisable but almost imperative, both as a matter of convenience and also to facilitate work, that prompt and reliable communication between the underground workings and the power-house shall be possible.

The rapid increase in the number of electric plants for mining or kindred purposes has made anything like a complete statement regarding them almost impossible, and this article has simply given examples of each class, chiefly to call attention to the possibilities presented.

That electricity presents for the transmission and distribution of power for mining purposes a system of great simplicity, completeness, efficiency, flexibility and economy, may now be considered as demonstrated by practical experience.

PROGRESS IN ORE DRESSING IN 1894.

By Robert H. Richards.

During the year 1894 it cannot be said that any great or marked advance was made in the mechanical treatment of ores and minerals. Nevertheless, many minor improvements can be recorded, and much has been written for the technical papers and societies upon this subject. The general tendency has been in the direction of securing closer working in concentrating and milling machinery, more economical methods, and an increased degree of automatism in handling ores, and toward the better cleaning and preparation of coal. The technical literature of the year included much concerning the treatment of gold ores, but little with regard to silver.

In reviewing briefly the progress which has been made, the order of arrangement that has been adopted is as follows: Crushers; washers; ore dressing and concentrating plants; coal washing machinery and plants; theoretical papers and description. Where the papers are of a practical kind and contain descriptions of plants or methods they are included under the first, second or third heading, according to their nature.

CRUSHERS.

Under this head may be included some improvements made in older machines, and also some new machines which have been introduced during the year. The Bartsch rock-breaker* is a crusher somewhat on the principle of the well-known Dodge crusher, resembling that machine in having its greatest movement upon the larger lumps, but differing in giving a considerable up-and-down motion upon the smaller fragments. This is obtained by placing the eccentric rod in a horizontal instead of a vertical position, and pivoting the jaw at a further distance from its lower end.

A new stone-breaker manufactured by the Farrel Foundry and Machinery Company of Ansonia, Conn., is intended for breaking rock for road-making; it differs chiefly from the established Blake type of crusher by the strengthening of certain parts and by the use of steel wherever possible.

The well-known Stedman disintegrator is a modification of the Carr disintegrator made by the Stedman Works, Aurora, Ind. It has received some

* *Zeit. für Berg- Hütten-und Salinenwesen*, 1894, p. 231.

improvements in detail intended to adapt it specially for coal-crushing preparatory to coke-making, and for this purpose it has been used at several mines with success.

Hotop describes an oscillating ram devised by him for pushing forward clay fed into Cornish rolls.*

The Frisbee-Lucop wet mill, made by the company of the same name in New York City, is a roller crusher of improved type which has been introduced in several places during the past year. The latest improvement in this machine consists in making the journal boxes of the cylindrical rollers slide in the driving head and arranging them so that the rollers can be run close against the ring die or at a varying distance from it. Fans are used to throw the material in front of the rollers, and also to throw the pulverized material from the rollers against the screens.

The well-known Huntington mill has received some improvements in detail, chiefly in the direction of strengthening the parts and substituting iron for wood in the framing wherever possible.

The Pfeifer mill† is a ball mill for dry crushing, having seven steel balls revolving in a circular ring and driven by radial arms attached to a vertical shaft. It is intended chiefly for grinding cement and similar material, and the designer claims that the wear is less than that of a ball mill with horizontal shaft.

During the year some progress has been made in introducing improved material in crushing machinery, with the intention of increasing the life of such machines and diminishing the wear of parts. Especially has this been the case with manganese steel.‡ This alloy has been introduced in several places for the jaws of crushers for rolls, wearing plates, and similar places with excellent results, the increased cost being, it is claimed, more than counterbalanced by the longer life of the parts and the better duty of the machines.

ORE DRESSING AND CONCENTRATING MACHINERY.

Under this head we may begin by referring to a small but convenient apparatus for testing ores devised and described by Mr. S. I. Hallett.§ This is a jig having a plunger with an adjustable eccentric, run by a hand crank and used for sampling and selecting small quantities of ore.

Otto Abeling invented an improved plunger mechanism for jigs‖ which consists of two semi-cylinders acting as a double cam. These can be arranged to give different strokes. The cam gives a slow lift to the plunger, a quick drop being obtained by gravity.

Mr. L. Seemann¶ writes of the influence upon the sizes of grains exercised by a centrifugal pump elevator. A pump driven 15.6 revolutions per second having a wing diameter of 0.272 meters and a circumferential velocity of 13.32 meters per second was subjected to four experiments with sand containing varying pro-

* *Thon Industrie Zeitung*, 1894, p. 628.
† *Thon Industrie Zeitung*, 1894, pp. 413, 442; *Stahl und Eisen*, 1894, p. 485.
‡ R. A. Hadfield, *Trans. Am. Inst. Min. Eng.*, Vol. XXIII., p. 169.
§ *Engineering and Mining Journal*, Feb. 10, 1894, p. 127.
‖ *Ibid.*, June 30, 1894, p. 607.
¶ *Freiberger Jahrbuch*, 1893, p. 83.

portions of galena. The water was then allowed to settle for a whole day; the description of sizes in one of the tests is given below.

	Grains over 2 mm.			Grains below 2 mm.		
	Mineral.	Lead.	Lead.	Mineral.	Lead.	Lead.
	Grams.	Grams.	Per Cent.	Grams.	Grams.	Per Cent.
Before experiment	145	1.9	1.3	855	6.1	52.2
After experiment	63	0.3	0.5	937	6.3	59.0

The other experiments showed very similar results.

Mr. L. Seemann* has described a new upward current apparatus, consisting of a small vertical cylinder placed within a larger cylinder, the annular space between the two cylinders being occupied by a screw thread of sheet iron inclined downward at an angle of 45°. The slimes enter at the lower end and are forced spirally upward; the discharge is arranged so that the heaviest sediment collects upon the lower part of the thread and is discharged into one compartment of the center cylinder, that upon the middle part of the thread into a second compartment, and that upon the upper end of the thread into a third. There are always three grades of the discharge and an overflow. It is claimed that this apparatus avoids the fault charged against the ordinary spitzkasten of discharging too thin pulp on the table, and of the spitzlutte of discharging too thick pulp. It is not said, however, whether this device has received sufficient practical tests.

Mr. H. J. Summerhayes has invented a hollow flange for the edges of concentrating belts, which he claims will flatten as it goes over the end rolls and then recover itself, the effect being to avoid the cracking to which the belt flanges are liable.

Mr. E. Ferrari describes the Riemenherd belt washer for fine sands and slimes,† in which a plain belt with flanges 0.7 m. wide is mounted on two end rollers, 4 m. from center to center and provided with bearing rollers about 0.6 m. apart. The belt is level lengthwise, but inclined in breadth. Pulp is fed on the higher side of the feed end and water on the upper side. It is stated that the jets of water used washed off five graded products, Nos. 1 and 2 giving heads, Nos. 3 and 4 middles, and No. 5 tails. This apparatus has been introduced at the Monteponi mines in Sardinia, where the material to be separated includes galena, cerussite, smithsonite and quartz. Machines of the size given have washed about 3 tons in 11 hours, only one boy being required to attend to each. The proportion of water required is about one and one half times in bulk that of the pulp at Monteponi. These machines are said to work much better than the percussion tables; the pulp is fed from spitzkasten.

A washing apparatus in use at the new separating works at Monteponi, in Italy,‡ was put up to treat an immense mass, estimated at 800,000 tons, of waste which had accumulated at the mines, being formerly considered too low grade for treatment. This ore carried from 13% to 18% zinc and about 1% lead, the minerals being carbonates and sulphides of zinc and lead and silicates of zinc.

* *Freiberger Jahrbuch*, 1894.

† *Oest. Zeit. für Berg- und Hüttenwesen*, 1894, p. 421.

‡ *Engineering and Mining Journal*, Sept. 22 and 29, 1894, pp. 269 and 293.

The gangue was chalk, gray feldspar and carbonate of iron. The total daily work of this plant is 250 tons of crude ore, yielding about 13% of concentrates.

In gold milling no very important changes are to be recorded, but a number of minor improvements have been introduced or suggested during the year. An improved mortar for stamp mills is described by Mr. E. E. Olcott.* It was designed for the Phœnix mill in Arizona. The mortar has a copper plate at the back but none at the front. It has three thin iron blocks under the screen which can be taken out one at a time as the dies wear. A steel plate can also be used to block up the dies when they are partly worn.

A new combination gold mortar for stamp mills, made by the E. P. Allis Company, Milwaukee, Wis., is designed for ore-crushing either with or without amalgamation. When used for amalgamation copper plates are placed on the feed and discharge side, and chuck-blocks are used to adjust the screens to the wear of the dies. The copper is attached to the block. The back plate can be reached through a covered opening, and is held in place by a key at each end, by which it can be adjusted to the varying heights of the die. When used for crushing without amalgamation, the chuck-block and copper plates are removed and the inclination of the screens increased somewhat.

An improved mortar for gold stamp mills, invented by H. Bolthoff and made by the Hendrie & Bolthoff Company, Denver, Colo., has the longitudinal surfaces below the feed and the delivery openings curved, permitting the use of large battery plates. It has also a movable feed apron which serves to keep the rear copper plate in position.

A "compromise" mortar called the Newton mortar is described by F. T. Snyder.† It is in use at the Newton mine at Idaho Springs, Colo. It is arranged so that it can be adjusted for high issue with amalgamation or for a low discharge for rapid crushing and concentrating. The mortar has a 7-in. splash-plate under the screen frame. For high discharge the height is 18 in., but by removing the splashboard the discharge is reduced to 11 in. The die is 6 in. high and to compensate for its wear the screen-plate is made thick on one side and thin on the other so that it can be reversed. In practice the copper plates have an angle of 50° and the screen angle is 12°, experiments having shown that these angles gave the greatest efficiency. The rear plate is held by keys and can be removed through the opening made for the purpose.

The Blanton cam for stamp mills, manufactured by Fraser & Chalmers, Chicago, is a cam attached to the shaft by a taper bushing or wedge which wraps around the shaft and is held in position by two pins. The action is such that when the cam does its work of lifting it tightens its wedge. The cam may be removed by striking it a few blows on the rear in the opposite direction from its normal work. At the mill of the Montana Mining Company, in practice, a shaft with 10 cams can be stripped and furnished with new cams in less than half an hour.

Among other improvements may be noted the use of an iron frame for a stamp mill by the Union Iron Works, San Francisco. The arrangement was made for places where lumber was costly and where skilled labor and materials for erecting

* *Trans. Am. Inst. Min. Eng.*, Vol. XXIII., p. 549.
†*Engineering and Mining Journal*, Dec. 1, 1894, p. 511.

the ordinary wooden frame were difficult to procure. The frame consists of two main posts, each of four channel bars riveted together. The top bar, the cam-shaft boxes and the base pieces are securely riveted to these posts.

A paper by Matthew Jamieson and John Howell* describes methods of mining and ore treatment at Broken Hill, New South Wales. The new mill was erected to treat the lower grade lead and silver ores. The ores are oxidized, containing carbonates and phosphates, and unoxidized containing galena. The mill as first constructed consisted of steam stamps of a capacity of 120 tons each, hydraulic separators and jigs, and proved to be ill adapted to the work, on account of the sliming of the ore and the imperfect sizing of the products. Subsequently it was changed to the present form of rock-breakers and Cornish rolls, followed by hydraulic classifiers, Collom jigs and revolving tables. With this machinery the lead is well concentrated but the silver very poorly. The tailings when rich enough are sent to the leaching plant to extract the silver. The plant uses 1,647,000 gals. of water per 24 hours. Owing to the scarcity of water, it is used over and over with a net loss of 30,000 gals. in 24 hours, which is equal to 176 gals., or 1466 lbs., of water per ton of ore treated. In practice 3.16 tons of ore yield one ton of concentrates. The dry silicious and kaolin ores are treated by stamping and pan amalgamation. The mill treats 200 tons per day. The stamps weigh 850 lbs. and make 95 drops of $6\frac{1}{2}$ in. per minute. There are 24 grinding pans and 24 amalgamating pans, which are of cast iron 4 ft. 6 in. in diameter and 3 ft. 4 in. deep, and the grinding pans make 40 revolutions and the amalgamating pans 80 revolutions per minute. These are followed by 12 settlers with cast-iron bottoms and wrought-iron sides 8 ft. in diameter and 3 ft. 6 in. high, making 1.4 revolutions per minute.

C. Blömeke describes† the new galena and blende concentrating works designed by Lührig, at the Dörnberg and Aurora mines in Westphalia. The mine ore is separated into lump (larger than 30 mm.) and mine fines (smaller than 30 mm.), and these are hoisted separately. The mine fines go to a preliminary trommel with 20 mm. holes. The lump from the mine is crushed in rock-breakers to 60 mm. size, and then goes to the trommel. The coarse, between 60 and 20 mm., is hand-picked with hammers, 20 men handling 150 tons in 10 hours. This ore yields galena, blende and concentrating ore. All below 20 mm. goes to trommels which have sieves of 12, 9, 7, 5.5, 4, 3, 2 and 1 mm. respectively, and thence to jigs with four or five sieves. The first sieves yield pure galena, the second and third mixed galena and blende, the fourth blende, the fifth included grains. The mixed galena and blende are separated by means suitable to their several sizes; the included grains go to stamps with a 2-mm. screen and this joins the trommel system. The material below 1 mm. in size goes to two spitzlutten and the overflow to spitzkasten with four spigots. The two spitzlutten spigots are jigged on five-sieve jigs. The four spitzkasten spigots are treated on Stein belts. A Salzburger table and a round table are used for finishing up these products.

Ch. Mouchet‡ gives some notes on washing minerals, particularly with Lin-

* *Proceedings of the Inst. of Civil Engineers*, Vol. CXIV., p. 132.
† *Berg- und Hütt. Zeitung*, 1894, pp. 141, 167.
‡ *Bulletin de la Société de l'Industrie Minérale*, Vol. VIII., p. 527.

kenbach tables, at the mines of Vaucron. The ore is argentiferous galena and blende with gangue of quartz, fluorite, calcite, pyrite and barite too intimately mixed to allow hand-picking. Ore above 25 mm. is picked for rejection of waste; sizes between 25 mm. and 4 mm. are crushed in rolls. This and the fines go to trommels 5.5, 4, 2.8, 2, 1.4 and 1 mm. These sizes are all jigged. The grains below 1 mm. go to a spitzkasten with nine spigots; the overflow from this to three spitzkasten with two spigots each. There are thus 15 spigots in all, the first delivering to a jig, the second and third to a jig, the fourth and fifth to a jig, the sixth and seventh to a Rittinger table, the eighth and ninth to a Linkenbach table, the tenth to a Linkenbach table, the eleventh, twelfth, thirteenth, fourteenth and fifteenth each to two Linkenbach tables. These Linkenbach tables are made of brickwork with Portland cement, 5 cm. thick or more, laid out with a sweep with a fall of .0419 to 1 m. They are 7.77 m. in diameter. The slime fed to table, 4500 kilos, carries 8% zinc and 2 to 3% lead; the galena product is 100 kilos, 65 to 66% lead; the blende product is 500 kilos, 38 to 40% zinc. The middling products are all ground in Heberle mills.

George T. Cooley,* in a paper on "Dressing Zinc and Lead Ores in Southwest Missouri and Southeast Kansas," gives the equipment for a modern dressing plant for 120 tons crude ore per 20 hours; it includes a 50 horse-power engine, one crusher 16 by 9 in.; two sets Cornish rolls 14 by 24 in.; one grizzly, sizing screens, spitzkasten, jigs and elevator. The included grains are recrushed and sent back for treatment, but the work seldom goes finer than jigging sizes. Three-sieve jigs are recommended for galena and quartz, 4 or 5 sieve jigs for galena, blende and quartz, with a gangue of baryta, etc. Jigs with sieves 36 in. to 42 in. long and 16 in. to 24 in wide, have a capacity from 35 to 60 tons in 24 hours. The water used is 2 cu. ft. per minute for each sieve. Fine sand or slime jigs, 12 to 15 tons for 24 hours, use 1 to 1¼ cu. ft. water per minute.

William P. Blake† treats of the separation of blende from pyrites. These minerals are so intimately mixed that they cannot be separated satisfactorily by jigging alone; accordingly the ore is put through the ordinary concentrating operation, yielding concentrates with 25% pyrite and 25% blende. The concentrates are then fed into a Blake roasting furnace, whereby the pyrite is converted into porous hematite and the blende and galena are practically undecomposed. It is again sized and jigged, yielding a product of clean blende of 60% and upward, galena, and iron ore for paint. It is found practicable to treat poor products, as low as 10% of blende. The roasting may be conducted so as to render the iron oxide magnetic and separate by magnetic concentration. But the jigging has been so satisfactory that magnetic separation has not been resorted to.

J. W. Meyer made experiments on magnetic separation of iron from blende, and after roasting a product carrying 35% zinc and 10% iron, brought it to 50% zinc and 4% iron.

E. C. Moxham‡ describes zinc smelting at the Bertha Works, Virginia. The ore dressing plant is 1300 ft. from the mine, with a fall of 200 ft. The ore is conveyed by a flume 12 in. wide and 6 in. deep with water. At the mill the ore

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* *Engineering and Mining Journal*, July 7, 1894, p. 9.
† *Trans. Am. Inst. Min. Eng.*, Vol. XXII., p. 569.
‡ *Engineering and Mining Journal*, Nov. 25, 1893, p. 544.

is forced through a grizzly, washed in a log washer to remove clay, and the lumps sent to a Blake crusher and rolls; the whole then goes to revolving screens, the fines from the last to spizkasten, and the overflow to a settling pond. These several sizes are treated, the largest by hand-picking, while the second, third, fourth and fifth are jigged on Parsons jigs. The spitzkasten spigots are jigged on Harz jigs. About 200 tons crude ore with 26% zinc yields 80 tons concentrates with 38% zinc.

The Heusschen process for separating minerals* rests on the principle that cleavable minerals are much more liable to decrepitate than massive, and that each mineral will have its own temperature of maximum decrepitation. Mixed minerals of the same size, if treated for decrepitation of one of them, may then be separated by a sieve. To accomplish this a metal table is suspended over a grate fire at an inclination of about 12°. The table is jarred lengthwise by a cam, which tends to cause the particles to travel rapidly down the slope. The ore is fed and discharged continuously; the decrepitated ore if sifted will yield the two minerals separate. In separation of galena and blende from baryta and schist the size was through 3 mm. on 1 mm., temperature 250° C. In 10 hours one furnace treats 1526 kilos ore of 8% lead, 23.3% zinc, 0.036% silver, yielding 1005 kilos of 16.4% lead, 29.9% zinc, 0.073% silver. Of the baryta 31% went into the tails and carried but 2% of the metals.

Mr. P. G. Lidner† describes ore dressing and concentrating in Sweden. The concentrating work in Sweden is confined almost wholly to zinc ores and to the silver ores of the Sala mines; the mills are of German pattern. The Ammeborg works, which may be taken as typical, treat ore carrying blende and galena so closely mixed that hand sorting is of little use. The ore goes to the crusher and thence to revolving sieves and the coarser part is picked into four classes, clean blende, clean waste, wash ore with galena, and wash ore without galena. The galena is sent away for treatment, the fine ore is again screened, washed and jigged.

An elaborate paper by Maurice Bellom‡ treats of the present condition of mechanical work in ore dressing in Saxony, the Harz, and Rhenish Prussia, giving many illustrations and descriptions of plants, showing the latest practice.

In the magnetic separation plant at the Monteponi zinc mines, Sardinia,§ the product handled is a middle-weight product that has been produced in the lead-zinc washing works, containing silicate and carbonate of zinc and carbonate of iron. The ore is fed to a revolving furnace, 32 ft. 9 in. long and 3 ft. 3 in. inside diameter, in which 12 tons of ore are roasted and 2 tons coal burned in 24 hours. The ore is cooled and sized to five sizes, each size treated by a magnetic machine which has radial electro-magnets and a cylindrical treating surface outside of the working poles. This machine makes from 12 to 20 revolutions per minute. The current is neutralized at one point in the circle and the heads drop off there. About 5000 tons, carrying 26% zinc and 10% iron, were treated during the first year and yielded 1530 tons concentrates and 41.7% zinc. With improvements since adopted this may be made 45%. The plant was installed by Signor E. Ferraris.

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* *Société de l'Industrie Minérale, Comptes Rendus Mensuels,* 1894, p. 98.

† *Trans. Am. Inst. Min. Eng.*, Bridgeport Meeting, 1894.

‡ Translated in the *School of Mines Quarterly*, Vol. XIV., pp. 218 and 330; Vol. XV., pp. 16 and 115.

§ *Engineering and Mining Journal*, Nov. 3, 1894, p. 415.

W. B. Phillips* discusses a recent bulletin of the North Carolina Geological Survey, in which H. B. C. Nitze describes magnetic concentration at the Cranberry mine. The ore below 10-mesh in size concentrates easily by Wenstrom's machine from 35% iron to 67% iron, while the coarse ore from 2 in. to ¼ in. in size concentrates only to 53% iron, and yields tails with 31% iron.

G. R. Johnson† describes the ore washer at Longdale, Va. The plant consists of 4 logs placed in pairs; the logs are of cast-iron pipe 17 ft. 5½ in. long, 11½ in. diameter outside and walls ⅜ in. and flanged at each end. There are two spiral threads made up of 8 spoons to a revolution; the blades are placed at 26° with the axis. Each pair of two opposite spoons are held together by two through bolts. The log revolves in a semi-cylindrical iron trough and makes 12 revolutions per minute, disintegrating the ore and conveying it to the revolving screen at the upper end. This screen is $\frac{3}{16}$ in. steel plate with $\frac{3}{16}$ in. round holes ½ in. center to center. The coarse ore is picked on Merry bumping picking tables. The water and fines pass to a 20-mesh sloping wire screen; the muddy water from the lower end of the washer is also passed through a screen. The fines from this and the 20-mesh screen go to the cars. A 25 horse-power engine drives the four logs and the revolving screens. The average of 6 days' work is 1479 lbs. coal burned per day; 196 tons crude ore washed; concentrates, 138 tons; hours run, 5.37½; cost per ton of washed ore for labor, 4½c.; coal burned per ton of ore washed, 10.6 lbs. The revolving screen lasts a year and treats 15,000 tons of ore before it is worn out.

Among other papers of considerable importance in this connection may be mentioned one by M. Gromier‡ on the dressing of spathic ore at Allevard, France; one by Mr. F. Kensington§ on the dressing of iron ores at Carbarceno, and one by Dr. W. B. Phillips‖ on the magnetic concentration of Alabama fossil iron ores.

COAL WASHING MACHINERY.

Rudolph Kolbe, engineer of the Miröschan colliery in Austria, has designed a drum for separating flat pieces in preparing coal for market.¶ The machine consists of a conical drum mounted on hubs with six spokes, the six divisions of the cone having each a band hinged along the edge which is forward in rotation. In operating the coal is fed at the small end of the revolving cone, and as it works its way toward the large end the flaps open sufficiently on the lower side to drop out slate and flat pieces of coal; should a fragment stick in the slot it is released on the upper side where the flap opens for a moment. Experiments made with this machine show that the coal passed through it gives a considerably smaller proportion of ash and waste than that which had not been treated.

At the David colliery, near Conradsthal in Silesia, a new coal-washing apparatus has been installed and is now in use.** The plant consists of a hopper with an oscillating feeding tray from which the closely-sized coal goes to an apron of

§ *Engineering and Mining Journal*, May 26, 1894, p. 490.
† *Am. Inst. of Min. Eng.*, Virginia Beach Meeting, February, 1894.
‡ *Bulletin de la Société de l'Industrie Nationale.*
§ *Proceedings Inst. of Civil Engineers*, 1894.
‖ *Engineering and Mining Journal*, Sept. 1, 1894, p. 200.
¶ *Colliery Guard.*, Aug. 3, 1894, p. 216.
** *Zeits. Berg- Hütten und Salinenwesen*, 1894, p. 234.

a slope somewhat steeper than the angle of friction. This delivers the coal to be washed in the top of a wide tube through which is forced an upward current of water with a pressure sufficient to lift the coal and force it over the feed edge, while the heavier slate and pyrites fall to the bottom. The coal is removed by an elevator and the water passed into a settling tank from which a centrifugal pump forces it back into the machine, while the waste is removed by a screw conveyor. In the plant at the David colliery about 1½ horse-power are said to be required for the pump and elevators, washing about 1½ tons of coal per hour; for this amount from 650 to 700 liters of water are required.

An improved Lührig washing plant, erected at Motherwell, near Glasgow,* in Scotland, is now in operation. A test made at this plant showed 2659 tons of coal washed in 35 hours, at a cost of 0.79d. per ton.

The use of coal-washing plants is increasing rapidly in England. An excellent plant erected at the Bridgewater colliery, near Manchester, England,† has a capacity of 350 tons per day. While the plant has no special new machinery the arrangement presents many points of excellence. The coal is delivered into a conical drum which yields slack below ⅜ in., also pea and nut coal. The slack is jigged on five Sheppard feldspar movable sieve jigs, the rubbish falling into a bin from which it is continually discharged by a screw conveyor. The fine coal passes into a settling tank whence it is conveyed into storing bins. The pea and nut are each washed on an ordinary Sheppard jig, the slate being removed by a valve. The rubbish removed by cleaning is from 10% to 15% of the coal. The water is used over and over again, being returned from the settling tank by a centrifugal pump.

In another English colliery near Normanton in Yorkshire‡ the mine coal goes to a grating made of iron bars set 3¼ in. apart. A screw conveyor and elevator then delivers the coal to a drum with five screens, which are respectively 2 in., 1 3/16 in., ¾ in., 7/16 in., and 1/12-in. holes; the first four are called nut-coal screens, the fifth fine coal, and the sixth dust. The nut coal is washed on a Baum jig and the coal is delivered into settling bins. These bins are drained and the coal allowed to dry before loading. It is claimed that this arrangement saves a great deal of breakage of the larger coal. The fine coal is passed through the disintegrator and sent with the dust to the coke ovens. As in the other plants mentioned, the water is used over and over again, the loss being about 10%. A very similar plant at the Middleton colliery§ in Yorkshire uses also the rotary screens and Baum jigs, but coarser sizes of coal are hand-picked. At this plant from 900 to 1000 tons per day are treated, and it is stated that pit coal, having from 20% to 25% of dirt, is brought up to good marketable quality.

The Baum jigs are also used at the Gelsenkirchen colliery,‖ in the Rhenish-Westphalian coal field in Germany. A plant near Wanne is very similar to those described above except that flat screens are used instead of rotary. At the

* *Journal Iron and Steel Inst.*, 1894, p. 511.
† *Engineering and Mining Journal*, July 28, 1894, p. 79.
‡ *Trans. Fed. Inst. Mining Eng.*, 1894.
§ *Engineering and Mining Journal*, June 7, 1894, p. 10.
‖ *Colliery Guard.*, April 27, 1894, p. 783.

Blanzy mines,* in the Pas du Calais in France, another similar plant is in successful operation, but the Raet-Madouse and Lemière jigs are used instead of the Baum pattern.

One of the latest coal-washing plants erected is at the Brakpan colliery in the Transvaal.† Here the screens give lump coal, small and large nut coal, about 5% of dirt and waste being removed, and 15% to 18% of unsalable slack and small coal going to the waste heap. At the Springs colliery near by, the nut coal is washed, the plant consisting of a mechanical tipple, a sizing screen, a picking belt, an elevator, revolving screens and two washers. Some inconvenience is caused at this colliery by the custom of transporting coal in sacks instead of in bulk, the sack generally used in the Transvaal carrying a little over 200 lbs.

A new arrangement of ore and coal-washing machinery applied in England‡ conists principally of a jig worked by a head of water somewhat on the principle of a hydraulic ram. The sieve hutch and plunger are of the usual Harz type, the sieve and plunger being each 35 by 15 in. in size. The plunger rod is pressed downward by a diaphragm actuated by water pressure in a pressure chamber, and is lifted by a spring. The water under the pressure of a 25-ft. column enters the chamber, which is 6 in. in diameter, approximately, above the diaphragm, pressing it down at the same time it pushes up the piston, 2 in. in diameter, against the spring and weight on the upper side of the chamber until the relief port is opened. The plunger then is raised by the spring, and this is followed by the fall of the small piston, when the operation is repeated. It is adjustable at 80 to 350 strokes per minute ; with 25 ft. head the capacity is 30 tons coal in 10 hours using 13½ tons of water or 0.038 horse-power.

An air separator at the Rhein Preussen coal mine near Homburg§ has been lately improved. At present there is used a long, narrow vertical flue ; the fine coal from the revolving screen falls into this flue and meets an air-jet from a fan blower directed toward it on an angle of about 32°. A branch discharge flue sloping at an angle of about 50° is provided for convenience for carrying away the dust. The coarser coal which falls through the winnowing air-stream meets a second air-current from a second blower, and here again a discharge flue is provided for carrying off the dust and the air current than passes into a large chamber and is allowed to settle. The fine coal in practice is about 30% of that fed to the apparatus and the remaining 70% of coarser coal goes to the jigs.

TECHNICAL PAPERS.

In the papers published in the technical journals and in proceedings of societies during the past year the discussion of gold milling machinery takes a prominent place. Mr. F. Chalon‖ reviews recent machines for crushing gold ores, concluding, that while other mills may be successful in working soft and medium ores, the stamp mill, in spite of all imperfections, still holds its own for hard quartz.

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* *Bulletin de la Société de l'Industrie Minérale*, Vol. VII., p. 293.
† *Engineering and Mining Journal*, Nov. 17, 1894, p. 461.
‡ *London Engineering*, Dec. 22, 1893, p. 758.
§ *Zeit. für Berg- Hutten und Salinenwesen*, 1894, p. 235.
‖ *Le Genie Civil*, Vol. XXIII., pp. 189-201.

Herr Schnabel* describes the mills at the mines near Tremnitz in Hungary, where the ore is quartz of a low grade, carrying about 0.25 oz. gold and 0.60 oz. silver to the ton with about 3% of pyrites. It is passed through Blake and Dodge crushers to Huntingdon mills of a capacity of 12 tons in 24 hours, requiring about 8 horse-power, and four amalgamated copper plates are used, over which the crushed ore passes and then goes to Frue vanners. The tailings from these go to slime tables. The concentrates from the vanners average about 0.87 oz. gold and 1.75 oz. silver per ton. About 70% of the gold is saved.

Mr. T. H. Leggett† says that in milling gold ore tests made at the batteries of the Standard Consolidated Mining Company in Bodie, Cal., show that 40-mesh steel wire screens give a considerably larger percentage of fines than punched tin, chiefly, he thinks, because the wire screens become more clogged by sand grains, small chips of wood, and similar refuse.

A new mill erected for the Orion Gold Mining Company in the Transvaal,‡ which was designed by Mr. C. T. Roberts, has a capacity of 160 tons daily. The ore goes through two Blake crushers before reaching the stamps. The special feature of this mill is that of its 40 stamps, 20 are of the English pattern made by Sandycroft, and 20 American by Fraser & Chalmers, the object being to give the two types of mill thorough tests.

Mr. F. M. Drake§ describes the stamp mill of the Wentworth Gold Fields Proprietary Company at Lucknow, New South Wales. The mill was designed to work a very hard diorite carrying free gold and auriferous arseno-pyrite. The ore goes from the grizzly to stone-breakers and bins. There are two batteries, each stamp having a finger for hanging it up, an unusual thing in Australia. The pulp is discharged on silver-plated copper plates, 14 by 4 ft., which are cleaned up daily. There is one mercury trap for two batteries and four Frue vanners. The stamps are 800 lbs., 6 in. drop, 87 drops per minute. About 90% of the gold saved is caught on the outside plates. The depth of discharge is 3 to 5 in. The stamps crush two tons each per 24 hours, and the gold extracted is 0.771 oz. per ton in bullion 810 fine, and 0.213 oz. per ton is left in the concentrates, which amount to 1.22% of the ore, and assay 17.45 oz. per ton gold and 2.35 oz. per ton silver. The average assay of tailings is 2½ dwts. per ton. The average life of the cast-iron shoes is 20 weeks, of the cast-iron dies 11 weeks, and of screens 6 weeks. The cams and tappets are of cast steel made in Sydney. The loss of mercury is about 4.75 dwts. per ton crushed.

M. P. Ferrand‖ describes gold milling at the Ouro Preto mines, Brazil. Ore from the mine is hand-picked, yielding an average of 40 tons for the crusher, 65 tons of fines, and 25 tons of waste per day. The works are arranged upon four floors, one above the other. The upper floor is devoted to crushing and hand-sorting; the other three have respectively 24, 32, and 40 stamps, with their amalgamating and washing apparatus. The crushers are Blake, Marsden, and Sandycroft; two of the mills are Brazilian, with stamps weighing 270 kilograms

* *Zeits. des Vereins Deutsche Ingenieure*, 1894, p. 52.
† *Engineering and Mining Journal*, June 30, 1894, p. 604.
‡ *London Engineering*, Nov. 17, 1893, p. 604.
§ *Engineering and Mining Journal*, Nov. 24, 1894, p. 489.
‖ *Le Genie Civil*, Vol. XXV., p. 164.

or 594 lbs., one is Californian, with stamps weighing 363 kilograms or 800 lbs., dropping 20 cm. or 7.87 in., 80 drops per minute. The general scheme is to concentrate on riffles and blanket tables, sending the best concentrates to a Freiberg barrel for amalgamation. The heavy sulphurets are concentrated and treated by chlorination; some of the lighter concentrates are washed with quicksilver in mechanical bateas 0.6 m. diameter and 0.15 m. deep. One of the machines used in the first concentration is called a "*table à retournement*," and is made up of three planks, each 0.5 m. wide, 4.5 to 5 m. long, with their edges put together, forming a triangular prism, which is hung upon end trunnions with a slope of 1 in 12. The three planes have each riffles 3.5 mm. high and edge-strips, and they come up in turn to receive their charges. What is caught in the riffles is rinsed off below. There are 58 of them for the 96 stamps.

Mr. E. R. Abadie* describes the system of gold milling at the North Star mine in Grass Valley, Cal., in detail. This mill was also described by Mr. T. A. Rickard† in an elaborate article on gold milling in Grass Valley, the instances selected by him to illustrate present practice being the North Star, the Empire and the W. Y. O. D. mills. This author draws conclusions as follows: He favors closely watching the height of discharge, and condemns punched tin plate as a substitute for wire screens. He finds the tendency is to increase the thickness of silver plate on the copper plates; thus the North Star mill has 1 oz. per sq. ft., the W. Y. O. D. mill has 5 oz. per sq. ft. He commends inside front amalgamated plates in the mortars, also the large plates of the W. Y. O. D. mill. He concludes that the California mortar is becoming an amalgamator, and the tendency to save in the mortar is increasing. He shows that the stamp mill is holding its own against other mills, and that the tendency is to give up the patent amalgamators and depend on plate amalgamation, concentration and chlorination for the best results.

Mr. G. F. Deetken‡ gave an interesting account of early quartz milling in Grass Valley, Cal., describing the first attempt at saving sulphurets made in 1857, and following the improvements in concentration up to the present time, when the best mills save, it is claimed, from 86% to 90% of the assay value of the ore.

Mr. T. A. Rickard§ in articles on gold milling in Australasia and on gold milling at Bendigo—part of a series of valuable papers on the milling of gold ores—gave a comparative description of several mills, showing the peculiarities of Australian practice. The subject of gold milling was further continued by Mr. Rickard in a paper‖ in which he discusses the limitations of the gold stamp mill. In this paper a very careful comparison is made between the California system of heavy stamps with a short drop and the Colorado system of light stamps with a long drop, finding that in the former the amount of crushing is much greater than in the latter; but at the same time there are features in each system which adapted it to the peculiar class of ore on which it is used. At the

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* *Am. Inst. Min. Eng.*, Virginia Beach Meeting.

† *Engineering and Mining Journal*, May 19, 1894, pp 460, 486 and 511.

‡ *Ibid.*, Oct. 27, 1894, p. 390.

§ *Ibid.*, Feb. 3, 1894, p. 101; Feb. 24, 1894, p. 174.

‖ *Trans. Am. Inst. Min. Eng.*, Vol. XXIII., p. 137.

Bridgeport meeting of the Institute this paper was discussed at much length by the author himself; by Mr. E. E. Olcott with a special reference to the material for the different part of stamps and for the use of rock-breakers, and by Mr. Philip Argall with reference to practice in the best Colorado mills, recommending rapid stamping and concentration before amalgamation for Gilpin County ores. With regard to materials for stamp mills, Messrs. W. F. Durfee, A. R. Ledoux and R. W. Raymond gave instances of the crystallization of iron and the injury done by constant vibration to the iron stems of stamps. Mr. A. B. Paul and C. S. Richardson called attention to the importance of using rock-breakers with the stamps, and Mr. Paul especially advocated the use of light stamps with a high drop.

Considerable attention has also been given during the year to the subject of concentration. Herr Helmacker* describes the building buddles used in washing tin ores; the diameters are $3\frac{1}{2}$ m. to 6 m., sometimes 15 m., the bottom slopes 15° to 17°. The size of the material is coarse meal (*rösche mehle*).

Mr. F. F. Sharpless† describes concentration at the Lake Superior mines. He gives a description of the dressing of Lake Superior copper-bearing rock, especially at the Atlantic and Quincy mines, concluding with a comparative table.

Mr. James Douglas‡ summarized in a paper American practice in crushing and concentrating machinery. The United States, he said, can claim well nigh every modern improvement in crushing machinery. The Blake, Gates and Comet crushers, the Ball stamp, and the California revolving drop stamp are all American. But in the line of concentrating machinery American inventors have devised few improvements, if we except hydraulicking. In discussing this paper Professor Munroe stated that the problem of ore dressing at Lake Superior, in the recovery of included grains, an efficient crushing machine is what is wanted. Professor Richards thought that Mr. Douglas had not done justice to American dressing machines. The old hog-trough hydraulic separator and the new positive hydraulic separator, the gyrating screens, the Collom jig, the Frue vanner, the automatic slate-pickers, are all purely American inventions and the spiked and fluted rolls for anthracite should be added to the list of American crushers. He considered the Harz jig a machine of much more universal application, while the Collom jig is a much handier jig with which to work. The claims of the Krom jig, the Frue vanner and of several forms of crushing mills were also advocated in the discussion.

In a paper on concentration Mr. Robert Edden Commans§ describes some late improvements in ore-dressing machinery. The author discusses hand-sorting, crushing, sizing, water-sorting, centrifugal separation, magnetic separation, and separation according to friability, and the methods of combining them in mills to give the best results. In discussing this paper Dr. Buss described the Lührig vanner; Mr. J. Head spoke of the concentration of iron ore by water and by the magnet; W. S. Lockhart described an upward current separator for separating

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* *Berg- und Hütten Zeitung*, 1894, p. 253.

† *Engineering and Mining Journal*, July 14, 1894, p. 33.

‡ *Am. Inst. of Min. Eng.*, Vol. XXII., p. 321.

§ *Proceedings Inst. of Civil Engineers.* Vol. CXVI., Part II.

gem stones from gravel ; F. J. King referred to a plant designed by him in 1874 for making spathic iron magnetic by heat, with a view to its subsequent separation from blende, saying that it was the first plant of its kind.

Mr. L. Seemann * discusses graded crushing, classing closely, and states that preliminary tests are too rarely made. The sieve scale, settled by calculation, calls for too many sieves. The limits of sizing can be greatly stretched without injuring the quality of the product. The power and the loss in attrition would both be saved by using fewer trommels.

O. Bilharz † discussed the nine rules of Rittinger concerning the design and operation of dressing works, and added a tenth rule. He criticized Rittinger's classification of plants and suggested as a substitute : 1. Works treating bituminous substances. 2. Works treating metallic substances. He then gave an outline of the processes and apparatus for cleaning coal and dressing ore. In discussing this paper Mr. T. A. Rickard remarked that dry crushing of free milling gold ores is unknown in the new mining districts of the world. Professor Richards suggested two more rules of ore dressing and also a classification of ore dressing plants. He emphasized the importance of crushing by stages and also the importance of intelligent hand sorting. Mr. J. C. I'Anson stated that coal washing is increasing and that the Lührig system predominates in Germany, and is thought favorably of in England, Scotland and Wales.

Prof. Robert H. Richards‡ discussed close sizing before jigging. The author has investigated the several laws of jigging brought forward by others, namely : 1. Equal settling particles. 2. Interstitial currents. 3. Acceleration, and has added a fourth law, Suction. His conclusions are that these four laws should give way to two others, namely, pulsion and suction.

Mr. J. T. Donald§ describes the present status of the Canadian asbestos industry. For separating the lower grades of asbestos fiber from the inclosing rock, W. G. Costigan & Co. of Montreal, have put up their cyclone fiberizing machinery in three of the most important mines—the Jeffrey, the Anglo-Canadian and the Bell. The low-grade asbestos, consisting of rock and fiber in intimate association, is fed to the machine in small lumps, which, meeting two rapidly revolving discs running in opposite directions, have their non-fibrous particles reduced to powder by attrition while the fiber escapes injury ; the grit is sifted out by a series of screens, which to a certain extent also separate the fiber of different lengths.

The list of papers might be much further extended ; but the list given above includes most of those having immediate practical application.

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* *Freiberger Jahrbuch*, 1893, p. 80.
† *Am. Inst. of Min. Eng.*, Vol. XXII., p. 225.
‡ *Ibid.*, February, 1894.
§ *Engineering and Mining Journal*, Sept. 29, 1894, p. 296.

ELECTROPLATING.

By Titus Ulke.*

Electro-deposition of Aluminum.—At the Tacony Metal Company's great plant near Philadelphia, aluminum is electro-deposited on the iron columns and plates for the tower of the Philadelphia City Hall. The coat of aluminum (aluminum tin alloy) here serves two purposes: First, it imitates the effect of stonework, and thus keeps the color of the tower in harmony with the rest of the structure; and secondly, it avoids the necessity of painting the ironwork to guard against corrosion. The *modus operandi* is as follows:

1. Preparation of the iron columns by boiling in caustic soda, pickling in acid, and scouring. 2. Plating with copper or aluminum bronze in an alkaline cyanide bath. 3. Plating with copper in an acid sulphate bath. 4. Plating with aluminum.

The plating apparatus is contained in a lofty and well-lighted building 120 by 60 ft. wide.

The size of the largest pieces—cast-iron columns 26 ft. long by 3 ft. in diameter at the lower end, and weighing between 5 and 6 tons—determined the size of the tanks. These are 28 ft. long, 4 ft. wide and 5 ft. deep, and hold about 3800 gals., with the exception of the tank containing the aluminum solution, which holds 7000 gals., and was made 8 ft. deep for special work. The tanks rest in cement pits, a little longer and wider but not as deep as the tanks, in two parallel rows of three each. When the solutions are run into the tanks water is at the same time admitted to the pits, the object of this being twofold, the water on the outside of the tank keeping it from leaking, and also balancing the hydrostatic pressure of the liquid within and preventing bulging. The plating current is furnished by four dynamos, the largest of the kind ever used for purely electroplating purposes, through copper conductors 6 in. wide by $\frac{1}{2}$ in. thick, which run underground and alongside the different tanks. These are insulated there with resin run in while melted. The columns and other pieces are brought into the electric circuit by wires passed around them like slings and attached at the ends to a conducting brass bar above the tanks. Twenty feet above the center of each row of tanks are I-beams properly supported from the girders and continuing for 30 ft. outside of the building, on which run trolleys with attached differential chain hoisting-blocks. The latter have a capacity of 3000 lbs. each. To the two ends of the column to be plated, spiders with a central projecting trunnion are fitted by means of set-screws, and wrought-iron slings with a bearing on one end are hooked to the tackle, and the end containing the brass bearing is passed over the trunnion. The column when hoisted is thus free to turn on its axis. The operation of plating a column is as follows: The column is placed on a truck resting on a narrow-gauge track, of which there are two running into the plating-shop. It is then run under the projecting I-beam, and the slings being adjusted, it is hoisted clear of the track. By means of a windlass fastened to the side of the building and ropes running over guide-pulleys it is then pulled along the I-beam over the first tank, which is of $\frac{5}{8}$-in. wrought-iron, and contains a

*The writer desires to acknowledge information kindly furnished by Mr. J. D. Darling, of Philadelphia, and by Mr. F. Schumann and Frank Shuman, of the Tacony Metal Company.

strong solution of caustic soda heated by a steam coil; it is lowered in and boiled for several hours until all the grease and oil are dissolved off. It is then raised, and after thorough washing with water from a hose, is pulled over and lowered into the second tank, and pickled with dilute sulphuric acid until all the rust and scale are dissolved and loosened. It is then taken to the extreme end of the building and thoroughly cleansed by the vigorous use of steel brushes and plenty of water. It then receives its first coat of copper in the third tank, which contains a cyanide solution of aluminum bronze. This is made by mixing cyanide of copper and cyanide of potash with aluminate of soda and a little stannate of soda. Here the column receives a coating of aluminum bronze 0.001 in. thick, deposited by a current of 1000 ampères at a pressure of 6 volts from the bronze solution contained in a tar-lined vat. This first coating may be of copper instead of aluminum bronze, as the bronze bath is only used at Tacony because of its convenience. The column is left in the bronze bath for about two hours, and is then removed and any sand-holes in it soldered, the copper or bronze giving a good ground for the solder to adhere to. It is then transferred to the second row of tanks, and after having been coated with paraffine wax inside, is lowered into the fourth tank, containing an ordinary acid copperplating solution. There it remains 24 hours, and receives a coating of copper $\frac{1}{16}$ in. thick. The tank containing the acid copper solution is constructed of 12 by 3-in. pine, lined with sheet-lead and covered with planks $\frac{1}{2}$ in. thick to protect the lead from injury. Two dynamos coupled together furnish the acid copper tank with a current of 4000 ampères at a pressure of 7 volts. A current density of 10 ampères to the sq. ft. is here employed, as against 3 ampères in the cyanide copper tank. Anodes of pure copper, suspended from brass conductors, are placed on each side of the vat. The electrolyte contains a nearly saturated solution of sulphate of copper and 7% of sulphuric acid. The copperplated columns, after having the paraffine boiled off, are now placed in the fifth tank, containing the aluminum bath. It was at first proposed to use pure aluminum for this finishing coat, but an alloy was substituted when the difficulty of depositing a thick coat of aluminum was ascertained, and when it was found that the addition of a certain amount of tin not only greatly increases the rate of deposition, but also renders the deposit more resisting to atmospheric influence. The alloy used at first contained from 5% to 10% of tin, but the proportion of tin has since been increased to 25% with greatly improved results, the latter deposit keeping its color better than that containing the smaller percentage of tin. The aluminum bath consists of a concentrated solution of aluminate of soda (obtained by electrically dissolving pure aluminum in caustic soda), cyanide of potassium, and 5 to 25 parts of stannate of soda for every 75 to 95 parts of the aluminate of soda, according to the alloy desired. A current of 2500 ampères at 5 volts, used for the aluminum plating, is satisfactorily furnished by an Eddy dynamo with a separate excitor. The aluminum plating tank is made of 3-in. cedar, coated on the inside with asphalt and placed within a vat made of cement 8 in. thick. The space left between the two vats, 4 in. wide, is filled with water. As the water in the cement vat stands at a little higher level than the aluminum solution, leakage of the latter is prevented by the over-pressure of the water. Any water leaking in serves to preserve the proper concentration of the electrolyte by replacing water lost by evaporation.

The aluminum plating solution is heated to about 130° F. by a block-tin steam coil. The anodes are of pure aluminum $\frac{3}{4}$ in. thick, 10 in. wide and 4 ft. long, and contain two short staples of copper for attaching the anodes. The conductors (2-in. brass and $1\frac{1}{2}$-in. brass rods) are moved out of the way when the columns are to be placed in the baths by counter-weighted cables and a windlass. The tank used for the deposition of the aluminum contains a total anode surface of 300 sq. ft. As the total current is 2500 ampères by 5 volts, this gives a current density of 8 ampères per sq. ft. of anode surface. One of the columns has a surface of about 150 sq. ft., which gives a current density at the cathode of about 16 ampères per sq. ft. An aluminum coating $\frac{1}{16}$ in. thick (or 2 to 3 oz. to the sq. ft.) is deposited in about 48 hours. The columns are rotated while in the bath. When stationary pieces are to be plated, the solution is kept in motion by means of a little screw propeller at the bottom of the bath and a paddle wheel at the surface attached to a vertical shaft. This furnishes sufficient circulation for the electrolyte. The iron columns, when they have received a bright coating of aluminum $\frac{1}{16}$ in. thick, are removed from the bath, washed with pure water in the sixth and last tank, and after a slight rubbing with brass brushes to brighten the surface, placed on a truck for removal.

The above described arrangement of the apparatus and methods of handling and plating some very large special castings exemplify good practice in electroplating on the largest scale.

Electro-deposition of Copper.—An approved method of electrotyping engraved copper map-plates is as follows: The plate to be reproduced (or a number of them brazed together to form one large plate) is backed with a coating of asphalt, silvered on the engraved side by being "sponged" with a dilute solution of silver cyanide, exposed to iodine vapor to form a separating film, and suspended in a deep vat as cathode in a wooden frame. From the "original" a raised copy ("alto") is thus produced, and the original, after being used for a few proof prints, is put aside. On the alto hung in the vat as cathode an extra copy of the original plate is produced in the same way, and this "basso" is then used for printing. The current is furnished by 10 or 12 Smee batteries—zinc and platinized silver or lead in a dilute sulphuric acid (1 : 20) solution, contained in rubber-coated boxes. Connections of the copper conductors are made in troughs filled with mercury. The electromotive force of the current is $\frac{1}{2}$ volt, and its intensity 120 ampères. The vat is of 2-in. board, lead-lined, and is 3 by 4 ft., and 4 ft. deep. Circulation is effected by dipping some of the solution from the vat and pouring it over a partition which reaches nearly to the bottom. The electrolyte consists of copper vitriol and just sufficient sulphuric acid to prevent "fungus" from growing in the otherwise neutral solution. From 6 to 8 lbs. of copper are deposited per 24 hours on the cathode, which hangs $\frac{3}{4}$ in. to 1 in. distant from the copper anode, in a vertical frame. It takes a week to produce a copper plate about $\frac{1}{8}$-in. thick. The "basso" plate is backed with copper in a shallow vat, by placing it horizontally on the vat-bottom, wrong side up, and suspending an anode of pure copper $\frac{1}{2}$ in. above it. A strong current may here be used and the copper rapidly deposited, as it must afterward be planed or filed smooth and level for the press. The copper deposited from a neutral solution is said to be harder, although

somewhat more brittle, than that deposited from an acid solution. The neutral bath, however, is said to "breed a fungus" which soon interferes with the deposition. As many as 3000 to 4000 prints can be made from one "basso." In order to be able to print a larger number of charts or engravings from the same plate "steel-facing" is sometimes resorted to. The plate in this process is suspended in a ferrous sulphate bath and a strong current passed through it for about 20 seconds; an extremely thin coating of iron of steely hardness is thus deposited on the "basso." From this plate very many more prints can be produced than from the plain copper plate. The operation of steel-facing, however, requires much skillful manipulation and it is therefore seldom employed.

Engraved zinc plates may be reproduced in the following way: The zinc original is covered with insulating varnish on the reverse side and with wax on the edges, its face cleaned from grease with benzine, then coated with a delicate separating film—preferably loosely deposited silver—and backed with copper in a cyanide bath. When a coating of copper is thus obtained sufficiently thick to protect the underlying zinc from attack by acid, a second coating can be secured by rapid electro-deposition from an acid sulphate bath. The copper will easily separate as an "alto" from the zinc plate, and may be used as a matrix for securing copies of the original plate.

According to Mr. J. D. Darling, the use of electrically deposited copper to protect and ornament architectural iron work is now firmly established, and a plating department is regarded as a necessary adjunct to all large iron works. Iron, when covered with a sufficiently heavy coat of copper, is rust-proof. For rolled sheets, or iron where the surface is smooth and free from sand-holes, from 8 to 10 oz. of copper per sq. ft. of surface will be sufficient. Where rough cast-iron work is to be plated, 14 to 16 oz. will be required. For inside work, where plating is used more for artistic effect than for protection, electro-bronzing (copper with zinc, tin or aluminum) is preferred, and a coat of 2 or 3 oz. to the sq. ft. will suffice. In France, where copper plating was first used to protect iron, the copper was not deposited directly on the iron, but on a coating of varnish, rendered conducting with plumbago, or with powdered copper, and applied to the iron surface and allowed to dry. This was done to avoid the difficulties of cleaning the cast iron, and the use of two solutions in depositing the copper, as the varnished article was placed directly in the acid solution. This method gives a coating that is not firmly attached and is liable to be torn off on coming in contact with any hard object. Examples of this system of plating may be seen on the lamp-posts of Paris and on the beautiful fountains of the Place de la Concorde and of the Place Louvois. By the method used in this country the copper is deposited directly on the iron, and a sheet of steel or iron so plated may be bent or twisted into any shape without the copper becoming detached. To attain this result the greatest care must be taken in cleaning and keeping clean the iron surface before immersion in the plating solution. The latter is a cyanide solution which, when properly made, is run cold and should deposit the copper in a bright state. Improvements have been made with the ordinary acid plating solutions, so that copper can now be deposited at the rate of 20 to 25 oz. per sq. ft., as malleable and almost as smooth as rolled copper. The density of the current can also be much increased over what was formerly believed possible.

Mr. Darling claims to have deposited copper $\frac{1}{8}$ in. thick at the rate of 10 lbs. per sq. ft. in 24 hours, as against the usual rate of 8 oz. in 24 hours, the deposition taking only one-twentieth the time usually required for obtaining a shell in electrotyping.

Gold Plating.—Either a hot or cold solution may be used, the former for small objects and the latter with large ones. Roseleur recommends the following baths:

1. Cold Plating Solution: Dissolve 1 oz. of pure gold chloride in $\frac{2}{3}$ qt. of distilled water and 2 oz. of pure cyanide of potassium in $3\frac{1}{3}$ qts. of water. These solutions are mixed and then boiled. The bath is preserved in proper condition by occasionally adding to it equal portions of cyanide of potassium and chloride of gold, a few grams at a time; if the bath is too rich in gold, the deposited gold is blackish or dark-red; if too much cyanide is present the plating is slow and the deposit turns grayish.

2. Hot Plating Solution: Dissolve 20 oz. of phosphate of soda in 3 qts. of hot water and $\frac{1}{3}$ oz. of gold in 1 pt. of water and add the second solution, a little at a time, to the first. Also dissolve 3 oz. bisulphate of soda and $\frac{1}{3}$ oz. cyanide of potassium in 1 pt. of water and add this solution to the two others. This bath may be employed at a temperature varying between 50° and 80° C., and is used for plating copper and silver objects. For gilding articles of iron or steel without the necessity of first plating with copper or nickel, a bath is used containing less soda phosphate and potassium cyanide, and a little more bisulphate. Copper, brass and cupriferous alloys in general are gilded directly, without even being previously amalgamated, but silver plated ware and articles of massive silver are generally given an intermediate coating of copper. Hot baths give a brighter-colored gold, and plate better and more rapidly than cold solutions.

In cold solutions a gold anode is used with a current of very feeble intensity and small electromotive force (1 volt), while in warm solutions an insoluble anode of platinum and a stronger current may be employed. By adding copper or silver solutions to the gold bath we may obtain reddish, rose-colored or so-called green gold. In order to secure a good deposit of greenish gold a yellow gold solution containing 0.8 oz. of gold to the gallon, with a silver anode, is recommended.

Nickel Plating.—In nickel plating establishments, where large and long vats requiring the handling of large quantities of solution are inconvenient, two sizes of vats, of small capacity but well adapted to the ordinary work, are commonly used: A trough-shaped vat 10 ft. long and 1 ft. wide, in which pipes and rolls may be nickel plated, and the ordinary vat, which may be about 38 in. long, 22 in. deep, 18 in. wide at the top and 4 in. at the bottom, for plating the more common articles. These vats, cheap in cost and yet durable, may be constructed of well-seasoned 1-in. pine, lined with tar. For the electrical power a small Hanson & Van Winkle dynamo, costing from $75 to $100, and furnishing a maximum current of 4 volts and 50 ampères, gives satisfactory results. The plating solution is made by dissolving nickel ammonium sulphate in boiling water, so that it stands at about 7° on Beaume's scale for acid at 60° F. The vat is filled to within 3 in. of its top with this solution. Nickel salt and a few drops of an emulsion of carbon disulphide in a borax solution—said to increase the "glance" of the plating—are added to the nickel bath, say once a week.

The plating solution is changed about once every three months. Lengthwise over the top of the vat, and insulated from it by rubber sleeves, are placed three ½-in. brass or copper rods; from the two outside rods the anodes—thick nickel plates—are suspended by means of copper hooks. These rods should always be kept bright with emery cloth, and should be protected from dripping solution. Before the objects to be nickel plated are put in the plating bath they must undergo a preliminary treatment of a mechanical and chemical nature.

Articles of iron or steel are prepared for nickel plating as follows: The rust is ground off with emery cake on a polishing lathe, or taken off from flat surfaces having raised characters by pouring over them a little muriatic acid; the article is then scratch-brushed until bright with pumice fastened to a copper wire, dipped in hot potash lye for half a minute, washed, and then suspended from the cathode-rod in the nickel bath. Brass objects are first placed in hot lye, or, if this does not remove all the stains, dipped in a solution of cyanide of potash and washed, then scratch-brushed with whiting and rinsed. Tinware is scrubbed with pumice, after treatment with lye. Zinc articles to be nickel plated should first be coppered.

In nickel plating, the number and size of the anodes used should bear a strict proportion to the work required; for example, small anodes should be used with articles of a limited surface. The objects to be nickel plated are left in the bath until they feel rough and look bright (whitish), say half an hour, unless extra thick plating is desired. If the nickel plating is blackish or dark in color, the excess of plating is cut off with red rouge and coal oil, or with tripoli and engine oil, on the polishing lathe. Re-nickeling is required when the article is scratched or streaked. In that case the scratches are removed with tripoli on a hard cloth wheel, and the article, which now has a dull surface, is placed in the bath. At the end of about two minutes it is taken out and cleaned, brassware with whiting and ironware with pumice. If the object is plated all over the surface, as it now should be, it is hung in again and the plating continued until the surface becomes slightly rough. The article is now taken out, washed in hot water, placed in sawdust, hard-buffed with red rouge and wiped with a soft rag, using soap and hot water to remove any remaining spots of rouge. Other good methods of nickel plating are practiced, but the above is that most generally adopted.

Silver Plating.—The plating solution is made by dissolving granulated silver in twice its weight of pure nitric acid (40° B.) and evaporating off the excess of acid from this solution. The nitrate of silver thus obtained is then dissolved in 10 to 15 times its weight of distilled water, and salt added to precipitate the silver as chloride of silver. The latter is filtered off, washed thoroughly with water, and dissolved in twice its weight of the best cyanide of potash and sufficient water to make a strong solution. This strong solution may be kept in a stoneware vat 1½ ft. deep and 1 ft. in diameter, and a little new solution added about once a week. When it has lost its strength it is poured into a larger tar-lined wooden vat and used as a weak silvering solution. In small establishments silver spoons attached by wires are generally used as anodes, a tablespoon as a large anode and a teaspoon as a small one, for plating table sets

and similar articles. There should be a distance of at least 3 in. between the objects to be plated and the anodes. Before they are silver plated, all common articles, excepting those of white metal and pewter, are best nickel plated. Previous to this they should be scrubbed with pumice stone. Instead of being nickel plated, copper objects are sometimes amalgamated. This may be accomplished by sponging them with quicksilver, or by dipping them for a few seconds in a solution of sulphate of mercury. When they have received a good bright nickel coating the articles are taken from the nickel bath, washed in cold water, and immediately suspended in the strong silvering solution. They are "struck hard," that is, the silver is rapidly deposited with a strong current, so that the solution foams for two or three minutes' with a comparatively large anode (size of tablespoon). Then the anode is replaced by a smaller one, and the objects taken out every 15 minutes and scratch-brushed until the silver coating is thick enough. Two coats are generally sufficient with a strong solution. If it is desirable to deposit a given weight of silver on any article, an anode of this given weight is used, and the plating continued until the latter has been consumed. The article is then washed in hot water, scratch-brushed with water, and buffed with red rouge. It is washed with soap and hot water, dried in sawdust, and soft-buffed for brightness with whiting. For silvering without current, a silver paste consisting of 12 parts of silver nitrate, 50 of sea salt and 30 parts of cream of tartar, finely ground together and mixed with a little water, has given satisfactory results.

Ship Copper Plating.

It has been found that a coating of copper will keep barnacles off the hulls, and will also prevent the pitting and corrosion to which iron and steel vessels are now subjected. By the process of Thomas S. Crane, patented May 30, 1893, and controlled by the Ship Copper Plating Company of New York, copper is electrically deposited in sections upon the surface of the vessel in successive rows, and the joints of the sections are overlapped during the electro-deposition in such a manner as to form an unbroken metallic sheet of copper and thus protect the entire surface of the vessel below the water line.

Mr. James N. George, president of the Ship Copper Plating Company, has kindly furnished the following interesting information :

The electroplating apparatus consists of a suitably shaped wooden vat, generally 5 ft. wide and 5 to 12 ft. long, which is applied to the hull of the vessel in such a way as to completely close the vat, with the exception of the upper side. The vat is securely shored up against the vessel's bottom, and calked around the edges with cotton and oakum till it is water-tight. It is then filled with a solution of strong sulphuric acid, which is allowed to act on the hull plates, covered by the solution. In about 6 to 24 hours time the acid will have dissolved or softened any adhering rust or paint. The acid is now run off, the vat taken down, and the specified portion of the hull thoroughly cleaned by scraping with files and wire brushes. The vat is then replaced, and filled with a solution of copper cyanide. Large copper anodes are placed along the lower side (bottom) of the vat, and connected with one pole of a powerful dynamo, by means of large copper conductors 3 in. wide by $\frac{1}{2}$ in. thick. The hull plates, on which the copper is

to be deposited, are brought into circuit by wedging the end of the conductor between the plates and the vat. A current of about 6 volts and 900 ampères is applied for 12 to 36 hours, and deposits a firm film of copper on the iron plates. The cyanide solution is now replaced by an acid solution of sulphate of copper, from which the metal is deposited with a current of 3 volts and several hundred ampères, or with a density not exceeding 7 to 10 ampères per sq. ft. of the surface to be plated. In two or three days the required coat of copper $\frac{1}{20}$ to $\frac{1}{16}$ in. thick is obtained. The vat is now removed and placed in position against the adjoining plates of the hull, but lapping over $\frac{1}{2}$ in. so as to make sure of a tight joint and secure an unbroken copper coating. Of course in practice a large number of vats are used at the same time, so that an ocean steamer of the largest size (600 ft. long) could be completely plated in about four weeks. The copper coating if properly deposited is so firmly attached that it cannot be removed except by forcible means, such as chipping with a cold chisel, in which case a portion of the iron usually comes away with it. There is no chance for galvanic action to set in except by a blow or grinding upon a rock, which might cut through the film. But after such a blow the vessel would undoubtedly have to be docked for repairs, and a small plating bath could be applied to re-copper the defective spot.

The tug *Assistance,* 90 ft. long by 19 ft. beam, and drawing $10\frac{1}{2}$ ft. water, has just had her hull electroplated with a coat of copper $\frac{1}{20}$ in. thick and covering nearly 3000 sq. ft. of the hull. This vessel, which left her dry dock Feb. 21, 1895, was plated to demonstrate the practicability of applying the above process on a large scale, and to prove that salt water has no effect on the coating by actual sea trials.

SOME METALLIC OXIDES, THEIR PRACTICAL PRODUCTION AND APPLICATIONS.

By Erik Enequist.

It is not intended in this article to treat such oxides as those of aluminum, cobalt, lead, manganese, etc., which have been in the market for many years, and some of which are even found in a native state, and the qualities and uses of which are familiar. There are, however, many oxides which have not been so well studied, and the qualities of which are not so well known as they should be for the best interests of several industries. Metallic oxides are very useful in the manufacture of glass, enamel, tiles, and for ceramic colors, etc., and are now quite important factors in these manufactures owing to improved methods of applying them on the china. The current price of these ceramic colors is about $2 per lb., and it is important for manufacturers of porcelain to know something about their composition, for metallic oxides, which are their chief constituents, should be pure and very finely ground.

The oxides are formed by exposing the metal to the action of oxygen, or they may be produced by ignition from the nitrates, and in some instances also from the sulphates. These methods, however, are not always economical and practical, and it is therefore necessary to treat each metal in a different way in order to produce the corresponding oxide. For pottery purposes it may be said that if the manufacture of the pure oxides was sufficiently known the competition in their production and sale would be more extended, and many manufacturers would be enabled, by the use of pure oxides and the proper fluxes, to produce practically all the colors needed in their manufacture, and at a moderate price.

In the following pages the different oxides and their production are treated in order.

Antimony Oxide (Sb_2O_3) is a yellowish-white crystalline powder, and is produced in various ways. The usual and the cheapest method is to roast the sulphide of antimony in a reverberatory furnace and to condense the fumes, which consist of antimony oxide. A somewhat purer oxide is, however, obtained by the use of metallic antimony, which is finely ground in a suitable mill and treated in an earthenware pot containing about 30 gals., with nitric acid or a mixture of nitrate of soda and sulphuric acid. Fifty pounds of nitrate of soda is dissolved in about double its quantity of water, and one gallon of sulphuric acid is added from time

to time. The pot is heated by steam or warm water in order to slowly expel some nitric acid; the powdered metal is thrown in small quantities into this hot mixture, when the antimony oxidizes freely. The product obtained is a mixture of antimony oxide and antimonic acid, generally of the formula Sb_2O_4. When the requisite amount of metal has been added the pot is heated still further and frequently stirred in order to oxidize thoroughly all the metallic antimony. The contents of the pot are now discharged into water, which is changed after the oxide has settled. At the end of the fourth washing the wash-water is of milky appearance, and the oxide is sufficiently pure to be dried and marketed. Another way of making antimony oxide is by dissolving sulphide of antimony or metallic antimony in *aqua regia* and then precipitating with an alkali. The product thus obtained, however, always contains some chlorine, and is neither a pure antimony oxide nor antimonic acid.

Antimony oxide is used in the glass industry for various purposes. It has been added to the extent of about 0.1% of the weight of the charge used in the glass-pot, and it is said that it purifies the glass and makes it flow more freely. It is added in large quantities to the glass when it is desired to produce an opalescent color. For this purpose the antimonic acid is far better than the oxide, as it is less volatile, and therefore combines more readily with the alkali in the glass. In the enameling industry antimony oxide is used to promote the affinity of the enamel for the iron and also its fusing qualities. The trade has objected to the use of antimony oxide, as it is known under certain circumstances to be poisonous; but when it is employed for enamel the oxide is either entirely volatilized or it is combined, and it would be absolutely impossible for it to have any injurious effect, as the enamel is insoluble, and the percentage of antimony contained in it is so small as to be of no consequence. By means of ammonium salts the antimony oxide may be volatilized from the enamel. Antimony oxide in a pure state is a suitable material for the manufacture of several medicinal preparations.

Chromium Oxide (Cr_2O_3) is an emerald-green powder of great hardness and resistance to chemical reagents. It is insoluble in all acids and alkaline solutions, and on account of these qualities it has been employed to great advantage in the manufacture of an indestructible green color. It is produced by mixing powdered bichromate of potash or soda with a corresponding quantity of flowers of sulphur and igniting this mixture in a reverberatory furnace. Sulphurous acid is evolved and the remaining substance is a mixture of chromium oxide and potassium or sodium sulphate. When most of the gas has burned away the residue is broken up, so that all the remaining sulphur is thoroughly burned out; otherwise this would contaminate the oxide and have an injurious effect in its employment. Instead of sulphur, powdered charcoal may be used, but by this process the color of the oxide is often impaired. Chromium oxide is also used in the production of the finer grade of crucible steel. Glass manufacturers employ it for producing an olive-green glass, and on account of its resistance to fire it is very desirable for this purpose.

Copper Oxide (CuO), also called *Cupric Oxide*, is a black powder and is easily obtained by heating metallic copper in the air or by roasting copper sulphide. It is obtained as a by-product in large quantities by burning copper-iron pyrites for the manufacture of sulphuric acid. When the cinders have been discharged

from the furnaces the copper is found as cupric oxide together with the iron oxide, and by exposing them to the action of the air and moisture and weak sulphuric acid, the copper oxide is dissolved and is drained away in the form of sulphate of copper, which may also contain some sulphate of iron, and out of this solution copper sulphate may be crystallized as blue vitriol ; or plates of metallic iron may be introduced into the solution, when metallic copper will precipitate on the surface of the iron and be easily recovered. Cupric oxide is also manufactured in a smaller way from copper scales. The scales are first finely powdered and then roasted in a reverberatory furnace. They are then reground and roasted again until the color is jet black. As the scales always contain some iron it is not possible to obtain pure oxide in this way. A more satisfactory method is to expose scraps of thin sheet copper in a reverberatory furnace for several hours, when the copper will oxidize thoroughly. By grinding and reburning, an oxide of satisfactory color is obtained which is nearly pure, but may contain traces of iron, etc. By calcining the pure nitrate a chemically pure copper oxide is obtained, and it can also be obtained from pure salts of copper by precipitation with an alkali and subsequent ignition.

Copper oxide has found a large and varied application in the industries. It has been used to great advantage in refining crude petroleum containing hydrogen sulphide gas. This gas is readily absorbed by the copper oxide forming sulphide of copper and water. The copper oxide can be regenerated by simply roasting this sulphide.

Cupric oxide is also used in the Edison-Lalande electric battery, which consists of a zinc element and one of copper oxide baked together in a suitable form and immersed in a solution of caustic potash or soda. This battery is said to be one of the most economical and durable in the market.

Cupric oxide is used for coloring glass green or blue, the color obtained depending upon the way the glass is manipulated. It is also used for decorative purposes in the tile and glazed brick industry, but can hardly stand the highest heat used in the kilns ; hence its employment is not always satisfactory. It is also an active oxidizing agent under heat and is employed to oxidize organic matters.

Cuprous Oxide (Cu_2O) is a bright red powder which will oxidize to some extent in the air. It is formed by treating a solution of blue vitriol or sulphate of copper with a solution of grape-sugar or glucose, which precipitates this oxide. The color is then yellowish and this method cannot be recommended as practical. The easiest and best way of producing cuprous oxide of satisfactory purity and appearance is to precipitate a solution of copper sulphate with metallic zinc, when metallic copper will form in a very finely divided state, provided the solution is stirred now and then and the zinc plates kept properly clean. The precipitated copper is collected on filters and dried for two or three weeks, when it will oxidize and become almost black. If the drying or oxidizing process is interrupted at the proper stage and the oxidized copper is enclosed in air-tight cast-iron vessels and subjected to a red heat in a reverberatory furnace for four or five hours, it is converted into a bright red cupous oxide of great brilliancy. Produced in this way the oxide is stable and will not oxidize in the air except under very favorable circumstances.

It must be remembered that prices of the metallic oxides are influenced to a great extent not only by their purity but also by their appearance, from which in most cases their commercial value is estimated, although many oxides may be perfectly pure and not of satisfactory appearance. It has always been difficult to produce cuprous oxide of a satisfactory color, and it is practically impossible to buy it anywhere and obtain it of a garnet color; this, however, can be obtained by the method described, which can also be recommended as being economical.

Cuprous oxide has been employed to advantage in the manufacture of a copper-ruby glass; this was very little known some years ago and its manufacture was a trade secret. Oxide or chloride of gold was used for this purpose, or a composition of gold and tin called "Purple of Cassius." While a pure cuprous oxide is required for this manufacture, the results are seldom satisfactory unless the glass is properly manipulated. After the glass has been made it is colorless, and the ruby color is only obtained by flashing or exposing it to the heat of the glory-hole. A mixture of cuprous and cupric oxides may be used to as much advantage as the cuprous oxide alone for the manufacture of copper-ruby, but in this case stannous oxide is employed also, as it prevents the cuprous oxide from being oxidized—or rather it reduces the cupric into cuprous oxide. In the manufacture of all copper-ruby some stannous oxide is employed. This manufacture, however, is still more or less of a secret. Comparatively little gold-ruby is manufactured now on account of the fact that the best copper-ruby is fully equal to it in appearance.

Iron Oxide or Ferric Oxide (Fe_2O_3) is found native in the form of hematite, etc., but when produced artificially it is a hard and bright red powder. On account of its hardness it is used extensively for polishing steel, glass, etc. Under the name of rouge it is used for polishing nickel, gold, silver, etc. The finer grades of ferric oxides are produced from copperas or crystallized sulphate of iron, which is evaporated to dryness in iron pans, then taken out as a hard mass and ground to a fine powder, in which state it is introduced into a reverberatory furnace, where it is roasted under slow heat. Ferric oxide is the result of this operation, as the sulphuric acid is volatilized in the furnace. The heat must be so regulated that practically all the sulphuric acid is evaporated; too high a temperature affects the color of the oxide, which has besides a tendency to bake together. This operation may take from 8 to 10 hours. When most of the sulphuric acid has been driven off, the powder is discharged and lixiviated in water, which will dissolve out all the undecomposed sulphate of iron and leave the ferric oxide as a fine precipitate. This precipitate is afterward floated, and being very fine it is utilized as a polishing material for gold, silver, etc. It readily commands prices as high as 25c. to 40c. per lb., while common ferric oxide, such as is obtained as a product after roasting ordinary iron pyrites, can be bought for $2 or $3 per ton. The mechanical qualities of ferric oxide are the important factors to be considered. Ferric oxide is used extensively for paint, but the native oxide answers very well for this purpose. The ferric oxide obtained as a by-product from iron pyrites always contains undecomposed sulphide of iron, which forms sulphuric acid and iron sulphate, or it contains some small quantities of metallic iron, beside grit, and cannot be utilized with any economy for polishing purposes or as paint.

Magnetic Iron Oxide (Fe_3O_4) is a combination of one molecule of ferrous oxide and one molecule of ferric oxide, and is obtained in the shape of iron scales in blacksmith shops or forges, as the hot iron oxidizes on the surface when forged. This oxide is quite stable and will not generally oxidize further in the air.

Magnetic iron oxide may be obtained artificially in a pure state and of an intensely black color by treating a solution of ferrous sulphate with nitric acid in sufficient quantity to oxidize two-thirds of the iron in the ferrous sulphate and then precipitating with caustic soda. In order to obtain the proper product care must be taken that the proper quantity of nitric acid is added. After this is done, the solution is heated and a caustic soda solution added, also in the hot state. The solutions must be hot and all air previously expelled; the wash waters must be boiled in order to expel the air, otherwise the product will be ruined. The properly prepared oxide has a beautiful black color and will not oxidize in the air. The first product is, however, the hydrated oxide, and in order to obtain the proper magnetic oxide it is necessary to expel the water contained in the hydrate, which can be done in closed cast-iron vessels. This oxide, as well as the ferric oxide, is used as a base for many mineral colors. In glass, these oxides produce a green or an amber color, depending upon the state of oxidation under which the glass is melted. Ferrous oxide may be obtained by precipitating the solution of the ferrous sulphate with caustic soda, with subsequent washings, but this oxide is not at all suitable for general use, and will absorb oxygen very rapidly in the air. Hence this method has little application for practical purposes at present.

Nickel Oxide (Ni_2O_3) is a brownish black powder which is obtained from the nickel preparations or salts by precipitating with caustic soda and subsequent ignition. The first product obtained is the green hydrated nickel, which is also marketed under the name of green oxide of nickel. Nickel oxide is used for producing a pale blue or a bluish-green color in glass, etc. It is employed quite extensively in glass manufacture as it neutralizes the injurious effects of ferric oxide, which is always found to some extent in the sand or quartz used by glass manufacturers. Nickel oxide has therefore taken the place to a certain extent of manganese, which is employed for the same purpose; but, it is claimed, gives less uniform and satisfactory results. Besides this oxide there exists a nickel mon-oxide (NiO) which is quite insoluble, and which is obtained as a main product in nickel manufacture.

Silver Oxide (Ag_2O) is a brownish black powder, which is obtained by precipitating a solution of nitrate of silver with caustic soda, then washing the precipitate until all the nitrate of soda that has formed is eliminated, and finally drying the oxide. It is used for the manufacture of fine opal glass and opal yellow glass. It is also used to a certain extent for ceramic colors. If the silver nitrate is quite pure, there should be little trouble connected with the manufacture of pure silver oxide. It is important that no traces of other metals be present; the presence of a little carbonic acid in the silver oxide does not generally injure it.

Tin Oxide or Stannic Oxide (SnO_2) is a white amorphous powder. It is quite hard and is used as a polishing material for glass. It is generally mixed with lead oxide and sold under the name of putty powder. It is manufactured

from metallic tin by melting it and pouring the hot metal into water, thus feddering the tin. In this state it is introduced into an earthenware pot containing hot dilute nitric acid. The feddered tin oxidizes quite readily and the metal is fed in from time to time. Water has to be added, otherwise the precipitate would not be obtained in a thin state. After the requisite amount of feddered tin has been added to the nitric acid the process is interrupted, water is introduced, the contents of the pot discharged and more water added. The tin oxide, which is properly stannic acid of the formula $H_2Sn\ O_3$, now settles to the bottom of the receptacle and after three or four wash-waters have been employed the last water becomes milky and all acidity is eliminated. Tin oxide can also be manufactured from metallic tin by heating it and condensing the oxide which volatilizes, which is then obtained free from water.

Besides its use for polishing purposes, tin oxide is a very important factor in the manufacture of all kinds of glazes in which whiteness is desired; also in the manufacture of enamel. A small quantity of the pure oxide will give enamel an intensely white color, and it is the best and most satisfactory material known for making opaque glaze or glass. The enameling industry consumes considerable quantities. Glazed brick and tile manufacturers also use large quantities of this oxide.

Stannous Oxide (SnO) is a dark gray powder that slowly absorbs oxygen from the air, but in contact with nitric acid or other oxidizing agents it oxidizes with great violence. This oxide is made by permitting fused metallic tin to oxidize in the air and stirring the metal constantly. The product is, however, always mixed with more or less metallic tin and it is difficult to obtain it in a satisfactory condition. A better method is to precipitate stannous chloride with carbonate of soda or caustic soda and wash the precipitate, taking care to use wash-water out of which the air has been expelled by steam. The lixiviated product is heated, with exclusion of air, and then obtained in a nearly pure state, owing to the affinity of this oxide for oxygen. It is employed in glass, enamel, etc., to prevent oxidization, as the stannous oxide will oxidize in preference to anything else. The precipitated stannous oxide has a very smooth and even appearance and must be kept in well-sealed packages. As above stated, it is also used in the production of copper-ruby glass. It is quite likely that this material can be put to more important uses when it can be obtained at a lower price than the present, which is about 60c. per lb. Moreover, very little, if any, of that in the market is of satisfactory quality.

The future of the metallic oxides is closely allied to that of the glass, enameled-tile and glazed-brick manufactures. If greater attention was given to experiments with pure metallic oxides to prove what they are capable of accomplishing, it is believed that great progress would be made, and encouragement given to further research in this direction.

THE RELATION OF THE MINING LAW OF THE UNITED STATES TO THE DEVELOPMENT OF ITS MINERAL RESOURCES.

By R. W. Raymond.

Enough has been written, perhaps, concerning the curious, haphazard origin of our unique mining law, and the innumerable disputes which its eccentric, vague, inconsistent and ill-considered provisions entail upon mine-owners—though, perhaps, all these things will need to be reiterated again and again before they will be realized by all the parties whose coöperation is necessary to a radical reform.

Enough has been written likewise, perhaps, concerning the object-lesson presented at this time by the mining districts of the world, including the greater part of the mining industry of this country, in which mining litigation (in the sense of disputes over the boundaries of mining rights, otherwise held by perfect title) is unknown, while in certain of our States and Territories such litigation burdens the courts, oppresses the owners and operators of mines, and enriches only lawyers and experts. This lesson also may need to be enforced hereafter by repeated exposition; but only because of the slowness of the pupils who should have learned it long ago. It is the purpose of this article, not to repeat the foregoing considerations, but to consider the present effect of the United States mining law upon the development of the mineral resources of that part of the country to which it applies.

Let it be conceded, for the purpose of this argument at least, that there was a time when the grant by the United States, to the discoverer of a mine on the public domain, of the right to follow the vein in depth, without regard to surface lines, was wise. I am perhaps the more willing to make this concession, because I was myself, at one time, an advocate of that policy. My first report as United States Commissioner of Mining Statistics, written in 1868, and transmitted to the Secretary of the Treasury in 1869, contains an argument in its favor. In the same volume will be found an able paper by Mr. W. S. Keyes, then residing in Helena, Mont., condemning the United States law, and frankly urging the adoption of the principle of vertical boundaries for mining titles. Mr. Keyes deserves the credit of this early protest. The law which Mr. Keyes at that time attacked, and which I (in this particular respect) defended, was the law of 1866, and not the subsequent "law of the apex" at all. The latter, passed in 1872, and intended to remedy omissions and defects in the earlier statute, has in fact introduced evils as numerous and as great as it removed; and, if there were no other grounds of demand for a radical change, the actual experience of nearly twenty-three years would be sufficient.

Further amendments of the present law have been proposed; but all of them retain the essential feature of the extra-lateral right, dependent upon the apex. So long as this remains the ultimate basis of mining titles, superficial and incidental amendments will do no good. The really pressing question is, Why should that abnormal and indefinable privilege continue to be attached, in certain parts of the United States, to the grants of mineral land made by the government? To this question, only two answers, so far as I know, have been offered.

1. It has been declared or assumed that mining prospectors upon the public

domain have a certain natural right to special reward for their industry and courage. There have been eloquent descriptions of these bold pioneers of civilization, who, braving the perils of inclement altitudes and savage foes, have pushed into the wilderness to discover the sources and lay the foundations of national wealth. While fully recognizing the merits of such early adventurers, I make bold to say that the age in which they deserved a special reward has passed away. There is no special danger or hardship in prospecting now. Indian wars are over; transportation through the West is easy and frequent; the general distribution of the mineral resources of the country is well known; and whatever is granted to the discoverer of a mine on public lands should be given, not as a reward for his personal enterprise, but in consideration of the benefit to be derived therefrom by the nation. Moreover, as will be incidentally shown below, the prospector is best rewarded by the grant of something definite, which he can safely hold or easily sell, rather than of something so vague as to be forever uncertain.

2. The other, and more rational, ground alleged in support of the policy of the government hitherto, is that it encourages the development of the mineral resources of the country, and is therefore justified as a measure of wise statesmanship. It is to this point that I shall chiefly address myself.

a. The word "development," as used in this proposition, is ambiguous. It may mean the revelation of sources of mineral wealth previously unknown, or the practical exploitation of such treasures by mining. In the former case it is fulfilled by the simple discovery of one mine, making known the existence of a new mining district. In the latter case it requires the establishment of a mining industry, involving not one, but many mines, and contributing to the wealth of the country. It is not to be denied that in the first sense "development" has its value. A man owning a tract of wild land may well encourage its examination by prospectors, and regard himself as enriched—though only prospectively—by the discovery of mineral outcrops upon it. But it is, after all, in the second sense only that "development" will bring actual increase of wealth; and it would be the height of folly for any such proprietor to grant, by way of reward to the first discoverer, privileges which would discourage later adventurers from contributing to this kind of development.

b. The period in which it was supremely important to discover new mining districts in the United States has practically passed away. Future discoveries will be mainly those of new mines in regions already known to be mineral land. The part of statesmanship, therefore, is to dispose of the property of the people in such a way as will encourage, not merely the first comer, but those later comers who will really exploit the resources of the country. Unquestionably this can be best secured by such a definition of the grant to the former as will make the acquisition of definite rights possible to the latter. And, unquestionably also, this cannot be done so long as a prior locator is clothed with rights not ascertainable from a study of the text of the United States grant itself.

c. The law does not even give to the first locator a certain and definite grant. It is true that the chances of litigation are somewhat in his favor. In certain contingencies his elder title takes precedence over those of later locators; but the dread uncertainty of apex and side-line questions hangs over him as well as over his rivals. These doubts and dangers unquestionably discourage purchasers.

The adventurous locator himself may be willing to take his chances in the struggle over questions of mining title which the law invites and provides for; but when he wants to sell out he will find that other people do not care to buy property with a fight attached to it as one of the "appurtenances." Now, it is perfectly plain—and I wish it were more thoroughly realized by our mining communities—that everything which discourages the capitalist injures the prospector. The law preventing aliens from holding real estate is a direct injury to the American owners of mines, whose market it restricts. Any law, practice, or public sentiment, which discriminates against corporations or non-resident mine-owners, is an injury primarily to the owners of mines which require for their active development the aid of outside capital. And the same is true of those features of the United States mining law which render litigation an inevitable and incalculable part of the expense of almost every largely productive mining enterprise. Surely there are risks enough in mining, without the addition of this utterly foolish and unnecessary one. The actual expense of litigations over mining titles under this law has mounted into the millions. Is anybody silly enough to suppose that mines subject to such an extra risk can be sold as easily or at as high a price as if the purchaser was sure of getting what he thought he was getting, and sure of being protected in the rights thus definitely acquired?

d. The mining industry of the West has reached a stage in which active development is more important than mere exploration of new fields and discovery of "promising" outcrops. There are good mines in plenty already known to exist. But the experience of years has shown investors that even the richest mines may have to pay for legal expenses more than they will have left for dividends. Silver-mining, in particular, cannot stand any longer these extra drains upon its income. I fancy there are some silver-mines, the proprietors of which would be better off to-day if they had had silver at only 60c. an ounce from the beginning, and no lawsuits over their boundaries.

The full development of the mineral resources of the West will never come to pass until the capital it requires is better protected by definiteness in title and boundaries of mining property. And that cannot be done, in my judgment, by any amendment of the present law which shall leave in it the present abnormal, irregular, indefinable, precarious and mischievous "extra-lateral right."

How many years longer will our Western fellow-citizens interested in mining continue to look upon the enormous investments of capital, and the amazing resultant development of wealth through mining enterprises, which characterize every mining State in the country where mining rights are bounded by surface lines and vertical planes only, and "the law of the apex" is not known? How long, I say, will this picture be contemplated and compared with the record of the regions under the incubus of this law, before an inkling of the cause of the difference will find its way to the minds of those who suffer most thereby?

If this comparison is too far beyond the reach of their observation, they might at least take note of the immunity from vexatious and ruinous conflicts over boundaries of mining rights enjoyed by placer-mines and coal-mines under their own eyes, and draw the obvious inference that a similar immunity conferred upon lode-mines would be a boon to all concerned.

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M. C. MUHLEMAN, Cashier United States Sub-Treasury, New York: "I wish to express my appreciation of the Mineral Industry. It contains so much material that it is impossible to 'surround' it entirely in a week, but in my study of the subjects treated, particularly the gold and silver statistics, I have already found some valuable additions to my stock of knowledge, and as it contains so much that has not been published elsewhere in available form, I know that I shall find it very valuable for reference."

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Revista Minera, Metalúrgica y de Ingeniería, Madrid, España, Junio 24 de 1893: "En este gran libro de 600 páginas de nutrida impresión no es sólo una estadística de la industria minera y metalúrgica, sino que es al mismo tiempo una historia de las explotaciones de minerales de los más remotos tiempos, así como una exposición de los procedimientios metalúrgicos nuevos y más interesantes, abordando también las cuestiones de tráfico, de coste de producción, marcha de mercados y cuantas pueden interesar á los que en cualquier sentido se ocupan de Minería y Metalurgia.

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Le *Génie Civil*, Paris, France, le 7 Octobre, 1893: "Un Journal de New York, The *Engineering and Mining Journal*, organe des mines et de la métallurgie, a publié la statistique minérale complète des États-Unis et du monde entier pour l'année 1892. L'ouvrage, un beau volume de 600 pages, constitue une véritable encyclopédie des mines et de la métallurgie. On y trouve la monographie de tous les métaux industriels, avec la description et l'indication de provenance de leurs minerais, l'étude des procédés métallurgiques nouveaux, les fluctuations de cours pendant l'année et des considérations économiques tirées de la comparaison de l'offre et de la demande."

The *Dixie*, of Atlanta, Ga.: "Mineral Industry . . . is a work which will be absolutely indispensable to every one interested in any department of the industry, whether as producer, as manufacturer, as merchant dealing in the mineral products, or as consumer. The information it contains has never before been collected, and it has great value to every intelligent man connected with the industry, and the volume will be kept on the desk throughout the year as a necessary book for constant reference. . . . This volume . . . gives the statistics to the end of 1892, or information just a year later and very much fuller than in the report of the United States Geological Survey just issued."

Rand & McNally's Monthly, of Chicago, Ill.: "Volume I. of this laborious work makes an addition to our library that we are not only greatly pleased with, but a feeling, we think, of just pride is added, that such a work comes from the American press, and from an American author. In the United States every man interested in mine-owning and working of mines and minerals will doubtless have this book without delay, and it must find its way into the libraries of thousands of others who desire the complete in their collection of permanent books. That able and thoroughly technical publication, the *Engineering and Mining Journal*, has our congratulations, being a co-operative associate of this work."

The *Florida*, of Ocala, Fla.: "When we first take up this unabridged encyclopædia of the mining industry we are surprised that so much can be put up for so small a price. As the volume opens and the superior quality of the work appears on every page, the wonder grows, and we are convinced that the miner or mining investor who does not have this book ready at hand is of that class which from its money is soon parted; and this work is much more prompt and available than if it had been done by the governmental artisans, who, like all people at a picnic, don't care a custard pie for the needs of a man back in the busy market, who must have some accurate knowledge on which to base his figures for a 'future' sale."

The *Journal of Geology*, Chicago, Ill.: "In conclusion, it may be said that as a piece of statistical work, relating to an industry that is world-wide in its scope, combining accuracy with full detail and systematic arrangement, and issued so soon after the close of the time to which it relates, the Mineral Industry has never been equaled in this country or abroad. . . . In the Mineral Industry we have an epitome of the mining operations of every quarter of the globe, published almost immediately after the close of the time to which they refer, a feat which heretofore would have been declared impossible. . . . The volume will be found of the greatest value to the economic geologist, the miner, the engineer and the business man."

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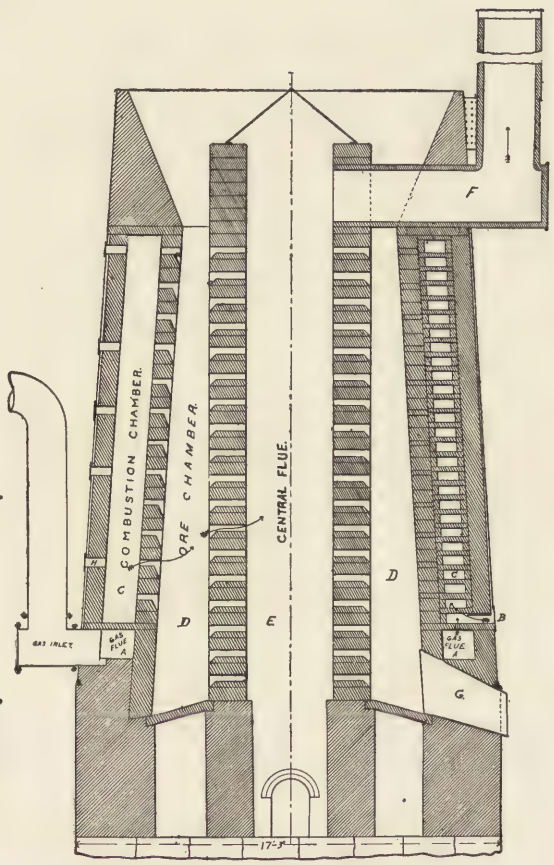

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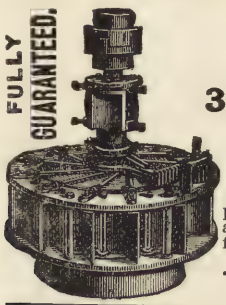

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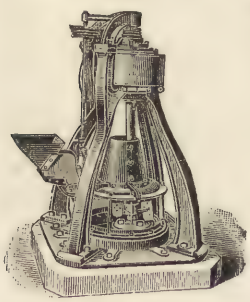

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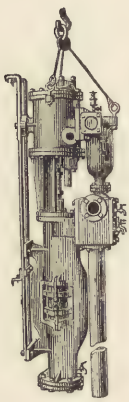

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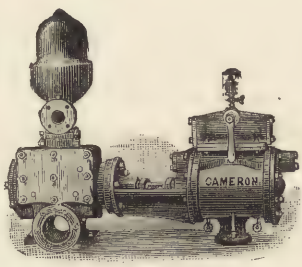

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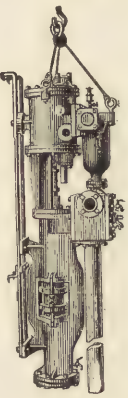

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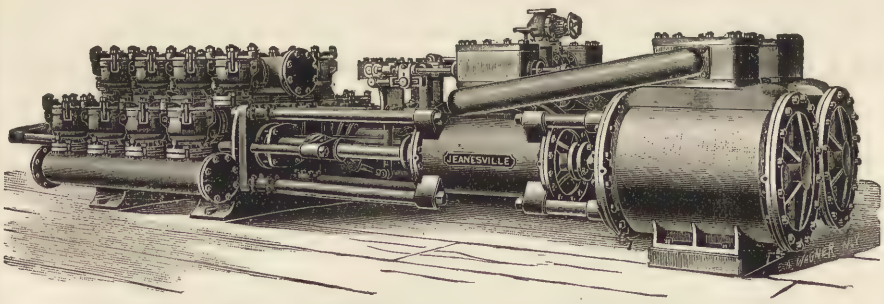

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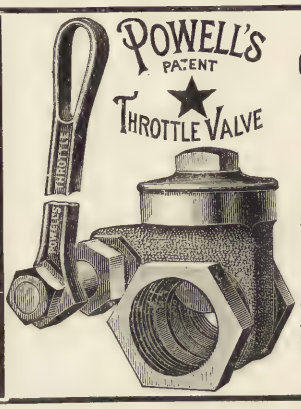

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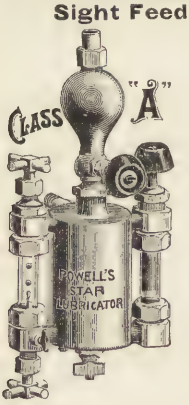

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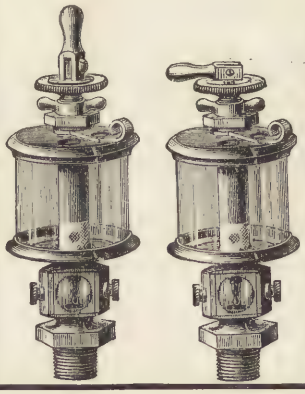

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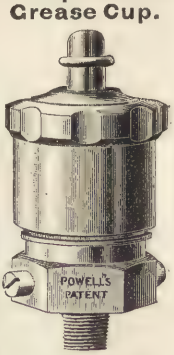

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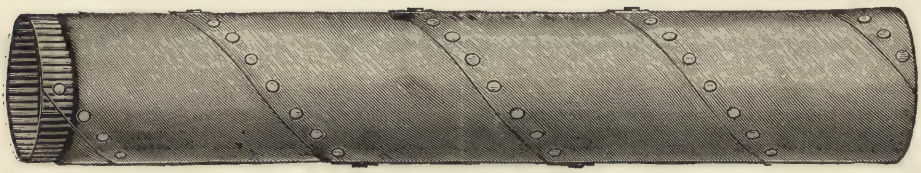

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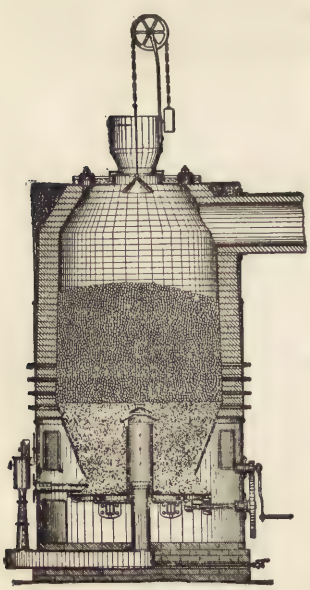

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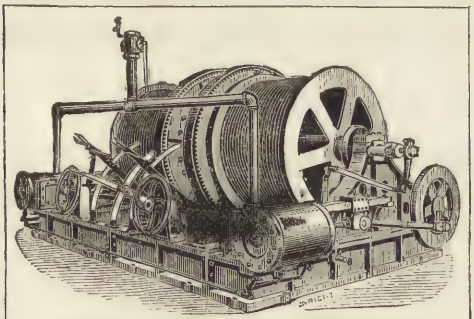

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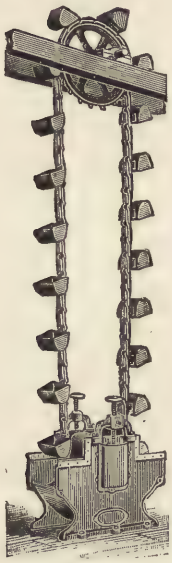

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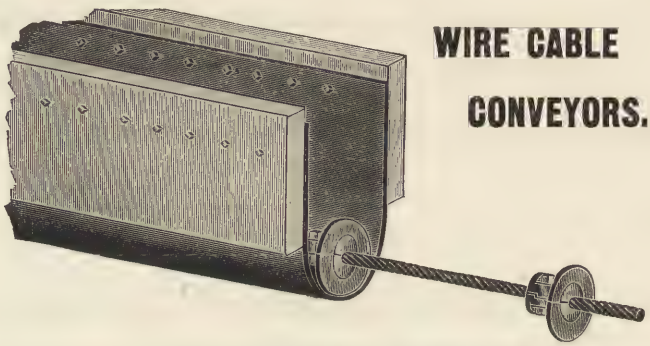

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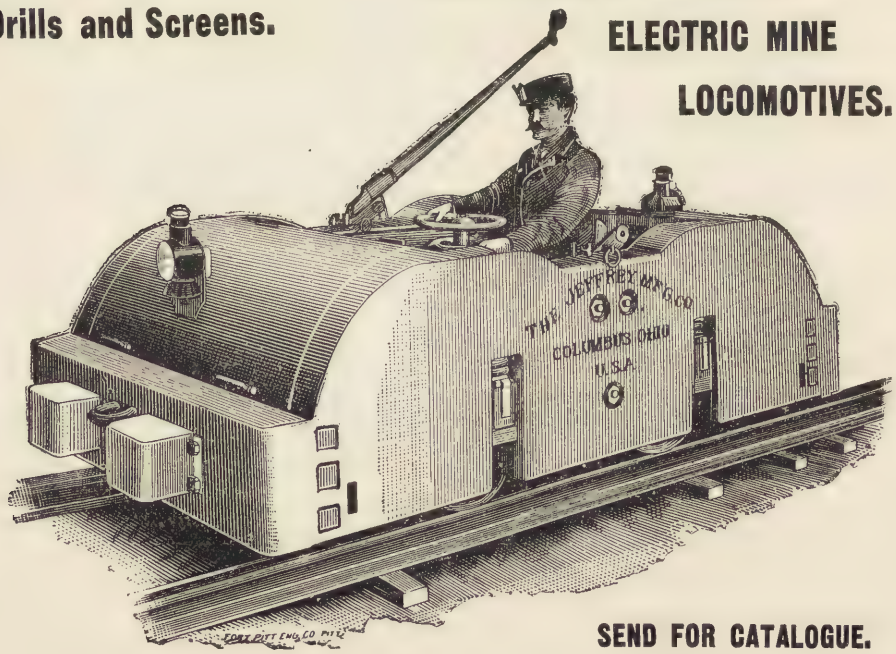

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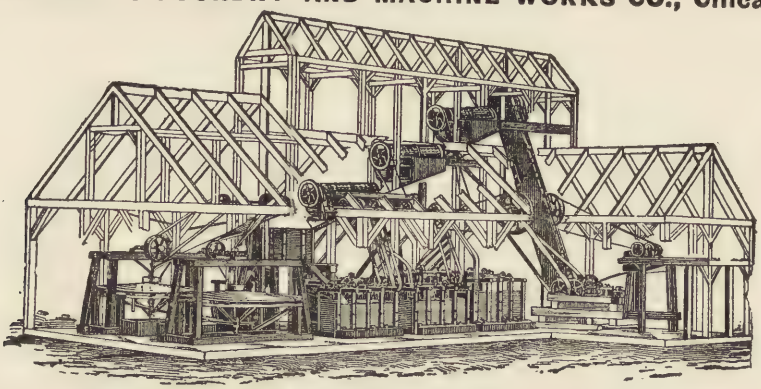

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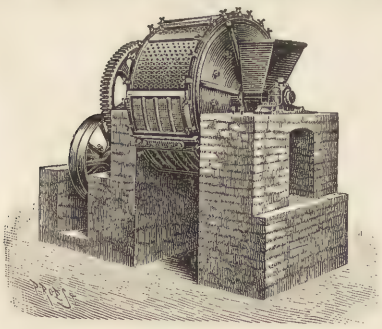

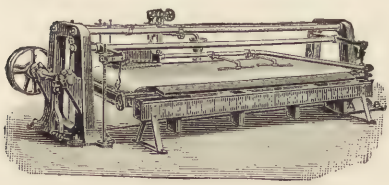

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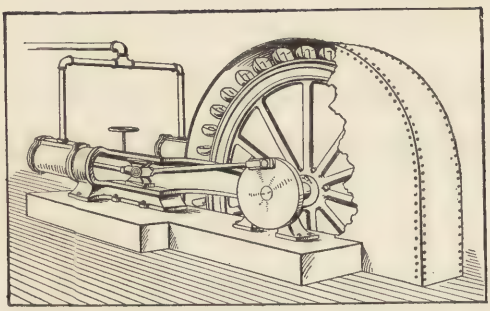

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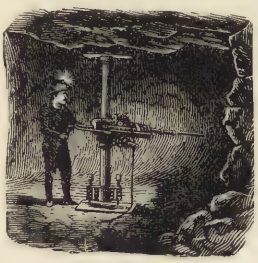

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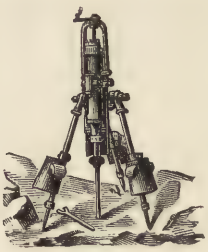

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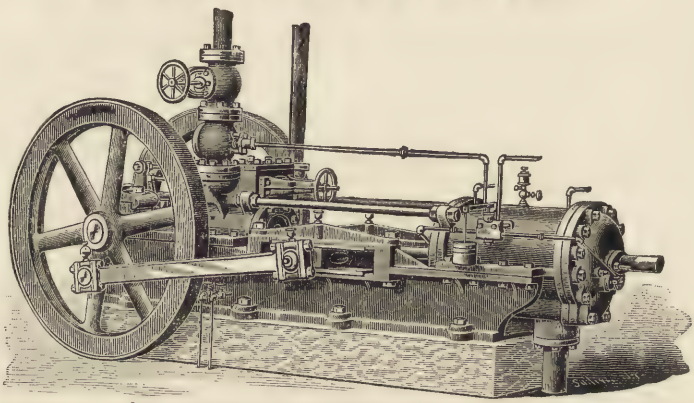

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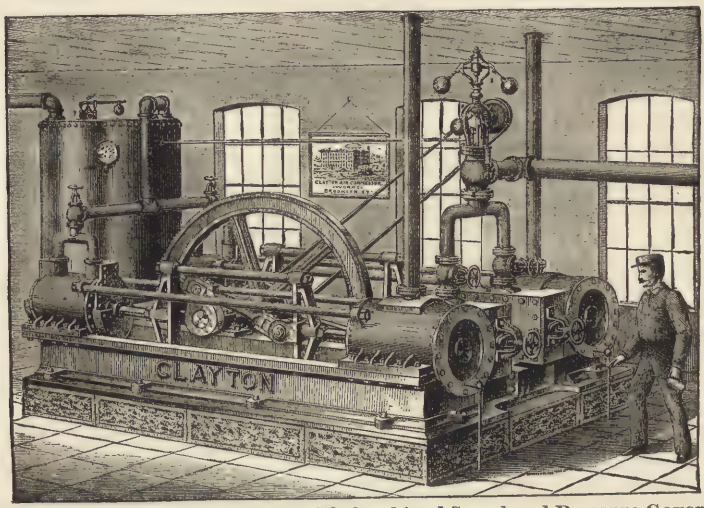

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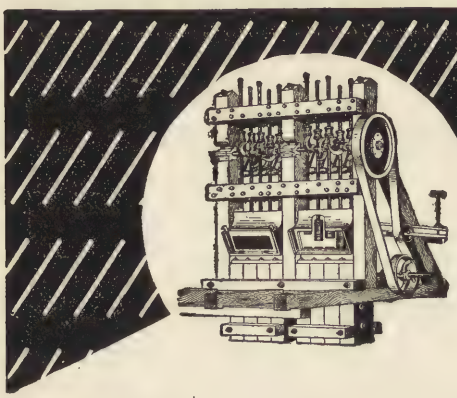

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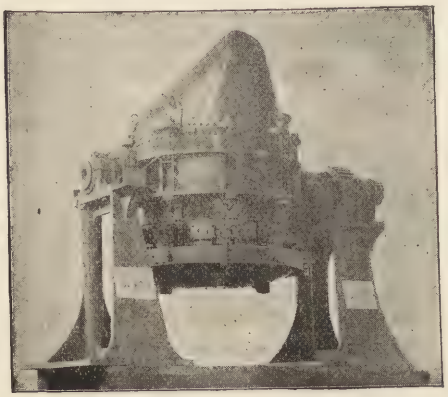

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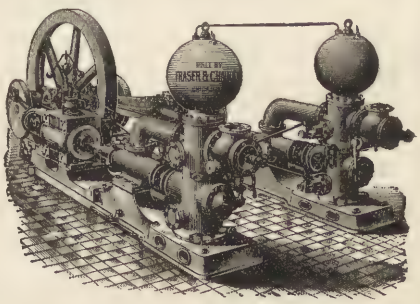

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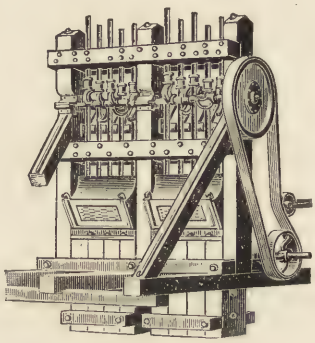

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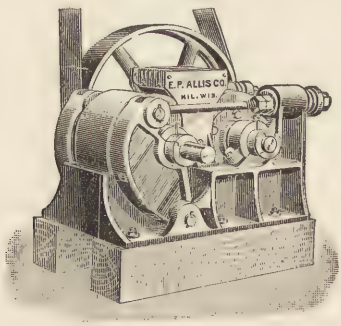

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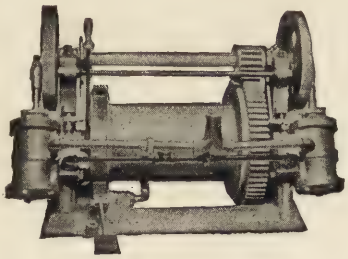

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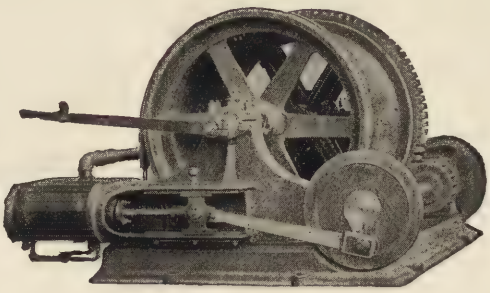

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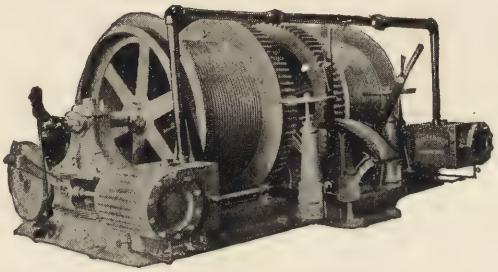

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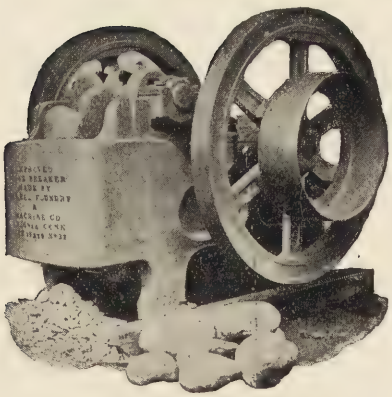

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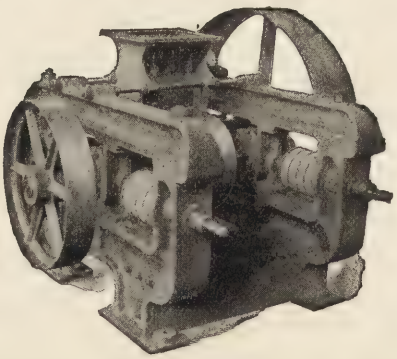

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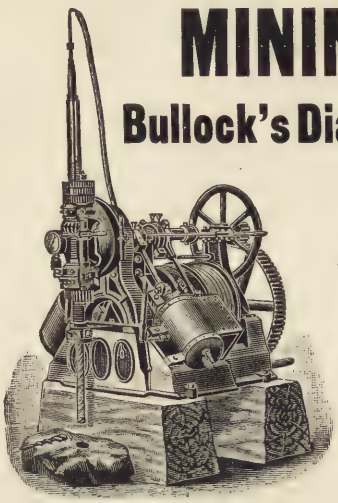

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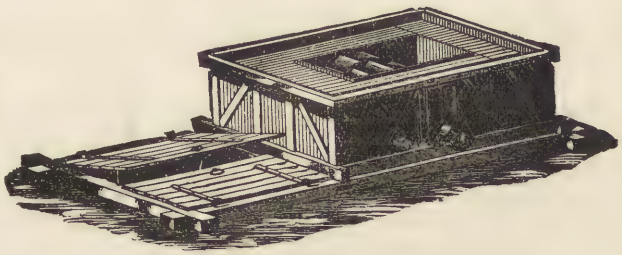

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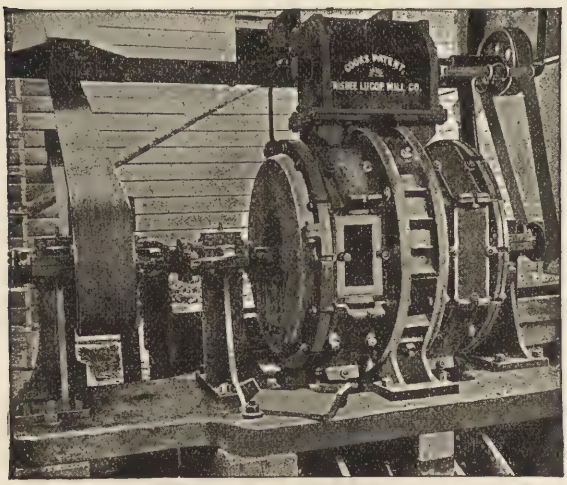

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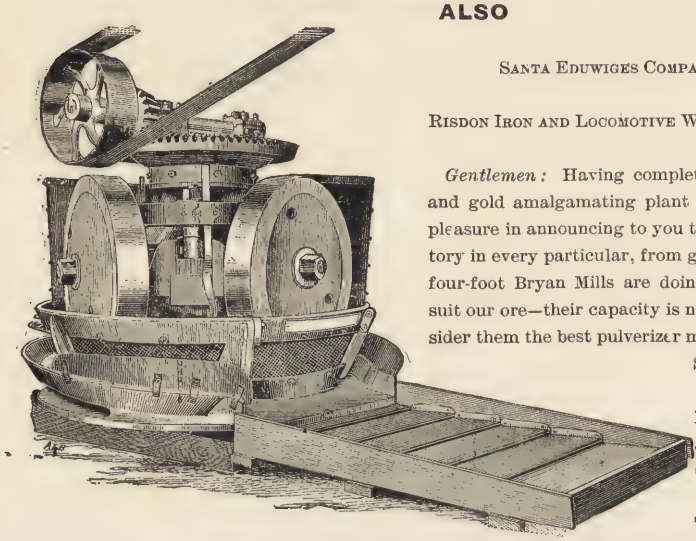

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